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**In-House Report**  
**July 1990**



**AD-A226 111**

# **MILLIMETER WAVE TWT LIFE TEST MONITOR**

**Leon L. Stevens, James Perretta, Curt Belusar**

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**Rome Air Development Center**  
**Air Force Systems Command**  
**Griffiss Air Force Base, NY 13441-5700**

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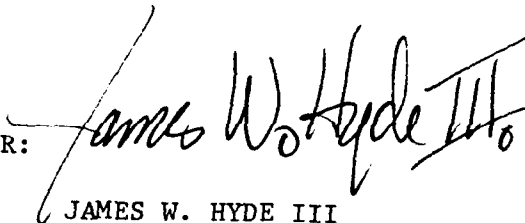
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13. ABSTRACT (Maximum 200 words) This report presents information on a monitor which can be used to capture and store life test data in real time. The hardware is specifically tailored to capture data without delay in real time. In addition to data acquisition, this report presents information on hardware and programs which can be used to transfer data to larger multitask computer systems where data analysis is more efficient. Because all multitask computer systems (even those as small as PCs) devote considerably amounts of time to tasks other than running the user's test program, they are not directly compatible with real-time data acquisition. Outside hardware is required to buffer real-time data and pass it to the computer system where final data reduction takes place. The interface hardware described in this report consists of two single task microprocessor systems. One system is based on the Motorola 6800 cpu with an SS50 mother board and SS30 input/output slots. The second system is a single board Motorola 6802 microprocessor.				
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#### INTRODUCTION:

This report presents both hardware designs and software programs which can be used to capture and store life test data in real time. The hardware is specifically tailored to capture data without delay in real time. In this way, we hope to be able to record the rare (perhaps once in 5 years), very rapid (perhaps less than 200 milliseconds) catastrophic failure of a millimeter wave traveling wave tube. Millimeter wave tubes fail quickly because their parts have relatively low thermal mass and their electron beams have high power densities. If one is able to record sufficient tube parameters during such a failure, one may be able to decipher the root cause of the failure and correct the defect in the next generation of millimeter wave amplifiers. In addition to data acquisition, this report will present information on hardware and programs which can be used to transfer data to larger multitask computer systems where data analysis is more efficient.

#### BACKGROUND:

Rome Air Development Center has been actively involved in the development of Millimeter Wave Traveling Wave Tubes since the inception of such devices. The classical method of determining the failure mechanism of a microwave tube is to do a postmortem (cut it apart and inspect it). However, millimeter wave tubes are so small and fragile that determining the root cause of the failure by this method has very low credibility. Either the physical opening process or some secondary damage mechanism tends to obscure any visible evidence of the initial failure mechanism. Millimeter wave tube amplifiers are so expensive that testing a few thousand devices to failure is not possible. Learning as much as possible from each actual failure is the most cost effective method to improving these devices. This system which senses the onset of failure and records all significant amplifier parameters during failure (for later analysis) appears to be a sound practical approach

to gaining knowledge about failure mechanisms.

#### LIFE TEST HARDWARE:

Because all multitask computer systems (even those as small as PCs) devote considerable amounts of time to tasks other than running the user's test program, they are not directly compatible with real-time data acquisition. Outside hardware is required to buffer real time data and pass it to the computer system where final data reduction takes place. The interface hardware described in this report consists of two single task microprocessor systems. One system is based on the Motorola 6800 cpu with an SS50 mother board and SS30 input/output slots. The second system is a single board Motorola 6802 microprocessor.

#### MILLIMETER WAVE TWT LIFE TEST PROCEDURE:

The following are typical parameters which would be continuously monitored:

Filament	(Heater)	Voltage	Filament
Current			
Focus Anode	Voltage		
Focus Anode	Current		
Body	Current		
Collector	Voltage		
Collector	Current		
Second Collector	Voltage	Second Collector	
Current			
RF Input	Power		
RF Output	Power		
Thermocouple	1		
Thermocouple	2		
Thermocouple	3		
Thermocouple	4		
Time & Date			

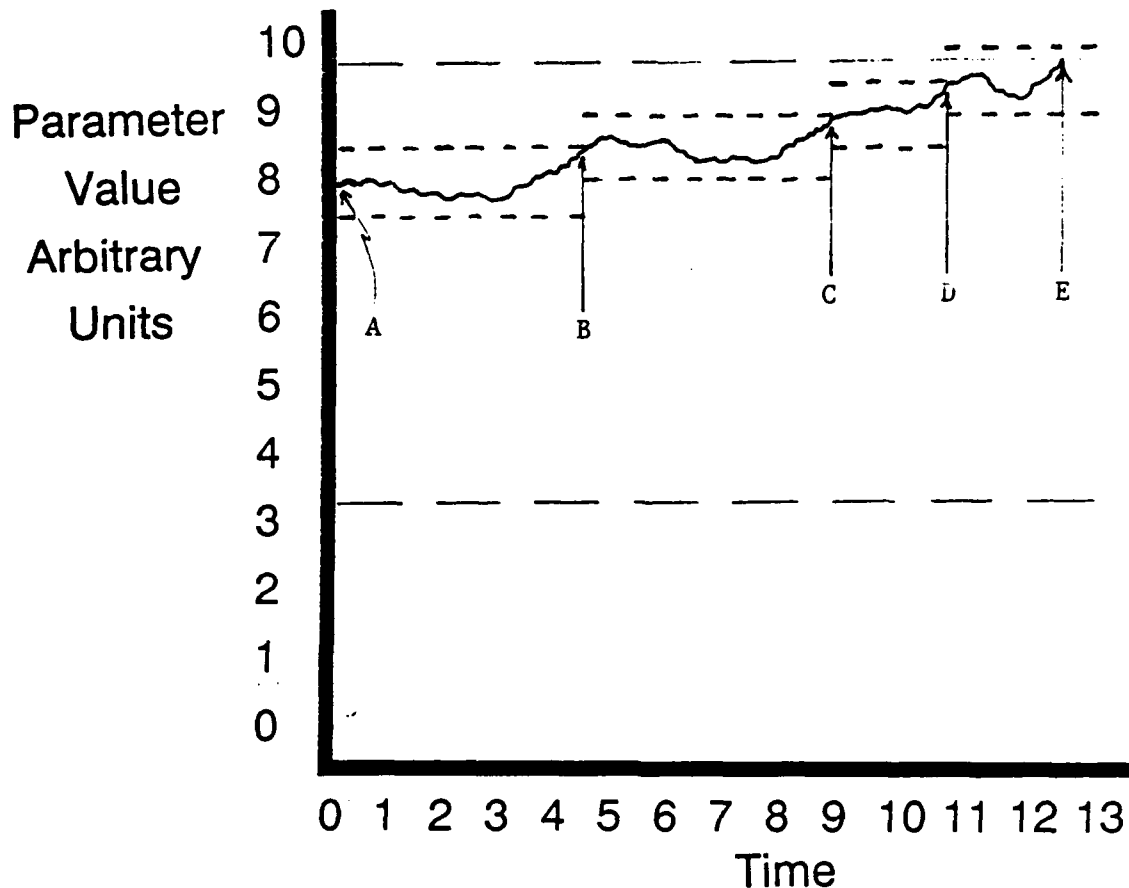


If as few as 16 parameters (four bytes each) are recorded every few (10) milliseconds, a fantastic quantity of data (200,000,000,000 bytes) is recorded each year. In fact a 20 megabyte hard disk is filled in less than an hour. Obviously the vast majority of this data is redundant and need not be recorded at all. It is only necessary to record data when a significant change has occurred in some parameter. As long as parameters are being compared against limits to determine if it should be recorded, it makes sense to compare the parameters against a second set of limits to determine if the tube under test is in a safe operating range, or if the system should be shut down (crowbarred) to protect the tube from damage caused by cooling or power conditioner failures.

In practice, the critical tube parameters are checked first to determine if crowbar is necessary. Next, each parameter is tested against its upper and lower limits of "normal" variation. If any parameter is outside its normal range, all the parameter values are recorded. To keep the system from triggering again on this same value, the "normal variation range" (of this specific parameter) is now centered about its current value. The recentering prevents redundant data from being recorded (as parameters slowly vary over their safe operating range) and still provides chronologic data on all significant parameter variations. Figure one on page four should make the test procedure more clear.

# Life Test Procedure

- Parameter Value = \_\_\_\_\_
- Safety Limits = \_\_\_\_\_
- Normal Variation limits = - - - - -



The safety limits were set based on theoretical considerations of the tube operating system.

The normal variation limits at point "A" were experimentally determined by recording the highest and lowest value of the parameter over a 24 hour period and multiplying that range by three. The normal variation limits were centered around the present value of the parameter when the life test commenced.

At points "B", "C", and "D" the parameter value hit the upper limit of the normal variation range. All parameters were recorded. The normal variation limits were recentered around the present value.

At point "D" the parameter value hit the safety limit. The system was shut down (crowbarred) and all parameters were continuously recorded until the recording media was full or standby power was lost.

(FIGURE 1)

## SINGLE BOARD MICROPROCESSOR SYSTEM:

{Please refer to the schematic diagram on pages 13 & 14}

IC-4 (Motorola 6802 8 bit microprocessor) is the heart of the system. It has a built-in clock which requires only a 4 MHz external crystal. In this application, external capacitors were added between the crystal leads and ground, to provide a stronger (more stable) clock signal. The sixteen outgoing address lines of IC-4 are buffered by non-inverting line drivers (IC-6 and IC-7). The address lines from the 6802 to the line drivers are labeled with small letters (a1, a2, etc.) The amplified address lines out of the buffers (IC-6 & IC-7) are labeled with capital letters (A1, A2, etc). The eight bidirectional data lines from the 6802 (IC-4) are buffered by IC-8. Small letters (d1, d2, etc) indicate data lines between the 6806 (IC-4) and the line driver (IC-8). Capital letters (D1, D2, etc) represent data lines between the bidirectional line driver (IC-8) and the rest of the system. This convention allows data and address lines to be labeled rather than drawn on the schematic diagram. The read/write output of the 6802 (IC-4) is buffered by one section of IC-16, and uses the same convention. The enable output of IC-4 is buffered by a section of IC-16, and uses the same convention. Valid memory address (VMA) is buffered and inverted by section B of IC11 (7400). VMA and E are combined in section A of IC11 to provide "NOT" of the quantity (E\*VMA). Buffered R/W is inverted in section B of IC12 (7404) to provide NOT (R/W).

All input/output (I/O) is memory mapped in the Motorola MC 6802, that is, no additional data lines or address lines are provided for I/O. The microprocessor merely reads from or writes to an apparent memory location, and hardware which decodes chip-select and R/W at that apparent memory location provides the real-world interface. IC-15 (MC6821) provides 16 bits of parallel

data interface between the microprocessor and the outside world. The 6821 is called a peripheral interface adaptor (PIA). IC-18 (MC6850) provides both a serial input interface and a serial output interface. The 6850 is an asynchronous communications interface adaptor (ACIA). IC-19 (MC14411) is a band rate generator chip. In conjunction with a 1 meg ohm resistor and a 1.8432 MHz crystal, it produces a variety of stable clock signals which can be used by the ACIA (6850) to clock serial data either in or out of the ACIA. Although the MC6850 is asynchronous (the same clock need not be provided to both ends of the serial communications link), the clocks must have the same (or very nearly the same) frequency.

Primary memory chip select decoding (including that for I/O) is provided by two 74154 decoders (IC-9 and IC-13) each 74154 has four bits of positive sense binary data input and one of sixteen lines of negative sense chip select as output.

The MC6802 (IC-4) has 16 address lines and can address 65,536 memory locations directly. To read a memory location the 6802 places the address of that location on the address lines, sets the R/W line to read (+5 volts) and sets VMA high (+5 volts). The address lines tell the hardware which location. The read line at +5 volts tells the memory location to place its stored data on the 8 data line. The VMA high is required because the microprocessor often puts garbage on the address lines while it is performing internal processing. Without VMA power would be wasted by selecting unwanted output drivers or worse yet garbage could be written into memory destroying the good data there.

One additional signal is required to write data into a memory location. The enable line (E) is used to synchronize when the memory chip should "capture" the information which is on the data lines. The 6802 places

the desired address on the address line, places R/W to write (zero volts), places E high (+5 volts), places the data to be stored in the memory chip on the data lines, and when the good data has been on the data lines as long as possible (for a given clock speed) pulls the E line to ground (zero volts). This falling edge of the enable (E) line is the signal for the memory location to capture the data now. Several chips like MC6821 and MC6850 have a direct connection to the buffered enable signal. However, some chips like the 5517 memory do not have a separate enable pin. These memory chips "capture" data when their chip select lines go high (they are deselected). To account for this, the primary memory select decode chips (IC-9 and IC-13) are only enabled when E and VMA are high. Not (E\*VMA) from PIN-3 of IC-11 is connected to NOT (chip enable) PIN-19 of IC-9 and IC-13. The VMA part of this control signal limits memory selection to valid memory addresses.

Address decoding for NOT chip selects is provided by IC-9 and IC-13. It is impractical to run all 16 address lines to each and every memory chip or I/O chip used in the microprocessor system.

Sixteen address lines allows 64K (65.536K actually) of direct access locations. The most significant binary bit (A15) can be used to differentiate between upper and lower 32K memory blocks (upper 32K when A15 is +5 volts and lower 32K when A15 is 0 volts). IC-9 and IC-13 have a NOT enable on pin-18. NOT A15 from pin-2 of IC-12 is connected to pin-18 of IC-13 (NOT enable). Thus IC-13 is enabled for the upper 32K block (\$8000 through \$FFFF). A15 from Pin-3 of IC-6 is connected to Pin-18 of IC-9 (NOT enable). Thus IC-9 is enabled for the lower 32K block (\$0000 through \$7FFF). Buffered address lines A14, A13, A12, and A11 are connected to the D, C, B, and A inputs of both IC-13 and IC-9. These four lines (representing 16 different states) break each of the 32K blocks down into 2K blocks (2,048 actually).

## ADDRESS IN HEX

\$0000 - \$07FF  
\$0800 - \$0FFF  
\$1000 - \$17FF  
\$1800 - \$1FFF  
\$2000 - \$27FF  
\$2800 - \$2FFF  
\$3000 - \$37FF  
\$2800 - \$3FFF  
\$4000 - \$47FF  
\$4800 - \$4FFF  
\$5000 - \$57FF  
\$5800 - \$5FFF  
\$6000 - \$67FF  
\$6800 - \$6FFF  
\$7000 - \$77FF  
\$7800 - \$7FFF

## CHIP SELECT GOES LOW

IC-9          PIN-1  
IC-9          PIN-2  
IC-9          PIN-3  
IC-9          PIN-4  
IC-9          PIN-5  
IC-9          PIN-6  
IC-9          PIN-7  
IC-9          PIN-8  
IC-9          PIN-9  
IC-9          PIN-10  
IC-9          PIN-11  
IC-9          PIN-12  
IC-9          PIN-13  
IC-9          PIN-14  
IC-9          PIN-15  
IC-9          PIN-16

## ADDRESS IN HEX

\$8000 - \$87FF  
\$8800 - \$8FFF  
\$9000 - \$97FF  
\$9800 - \$9FFF  
\$A000 - \$A7FF  
\$A800 - \$AFFF  
\$B000 - \$B7FF  
\$B800 - \$BFFF  
\$C000 - \$C7FF  
\$C800 - \$CFFF  
\$D000 - \$D7FF  
\$D800 - \$DFFF  
\$E000 - \$E7FF  
\$E800 - \$EFFF  
\$F000 - \$F7FF  
\$F800 - \$FFFF

## CHIP SELECT GOES LOW

IC-13          PIN-1  
IC-13          PIN-2  
IC-13          PIN-3  
IC-13          PIN-4  
IC-13          PIN-5  
IC-13          PIN-6  
IC-13          PIN-7  
IC-13          PIN-8  
IC-13          PIN-9  
IC-13          PIN-10  
IC-13          PIN-11  
IC-13          PIN-13  
IC-13          PIN-14  
IC-13          PIN-15  
IC-13          PIN-16  
IC-13          PIN-17

The eleven lower order buffered address lines (A0 through A10) are connected to IC-1, IC-2, IC-3, and IC-5. The five higher order address lines (A11 through A15) are decoded by IC-9 and IC-13. This information is passed to IC-1, IC-2, IC-3, and IC-5 in the form of an active low chip select (which is applied to output enable and chip enable). Thus the memory chips are fully decoded. Each memory is actually represented by a unique 8-bit memory location.

IC-18 (MC6850 ACIA) is not fully address decoded. This chip is selected by IC-13 at any of the 2K addresses between \$E800 and EFFF. However, only one of the lower eleven address lines is connected to IC-18. A0 is connected to PIN-11 (the register select line). If the microprocessor reads "memory" location \$E801 it gets the data register of IC-18. If location \$E800 is read it gets the status register of IC-18. \$E803 is the data register of IC-18 (the same as \$E801). \$E802 is the status register of IC-18 (the same as \$E800). \$E804 is the same as \$E800, etc. The same registers "echo" through the entire 2,048 addresses. All even addresses in this range get the status register because A0 is low. All odd addresses in this range get the data register because A0 is high. Actually, there are two more registers in the ACIA (transmit data and the control register). These are selected at \$E801 and \$E800 respectively when the microprocessor performs a write operation. These also echo through the full 2K. Unlike an actual memory chip where reads and writes done to the same location access the same storage register, a read and write to the same location in an ACIA access different storage registers.

IC-14 and IC-15 (MC6821) are not fully address decoded. A0 and A1 are connected to register select 0 and register select 1 respectively. In IC-14 \$E000, \$E001, \$E002, and \$E003 echo from \$E000 to \$E7FF. In IC-15 \$0800, \$D801, \$D802, and \$D803 echo from \$D800 to \$DFFF.

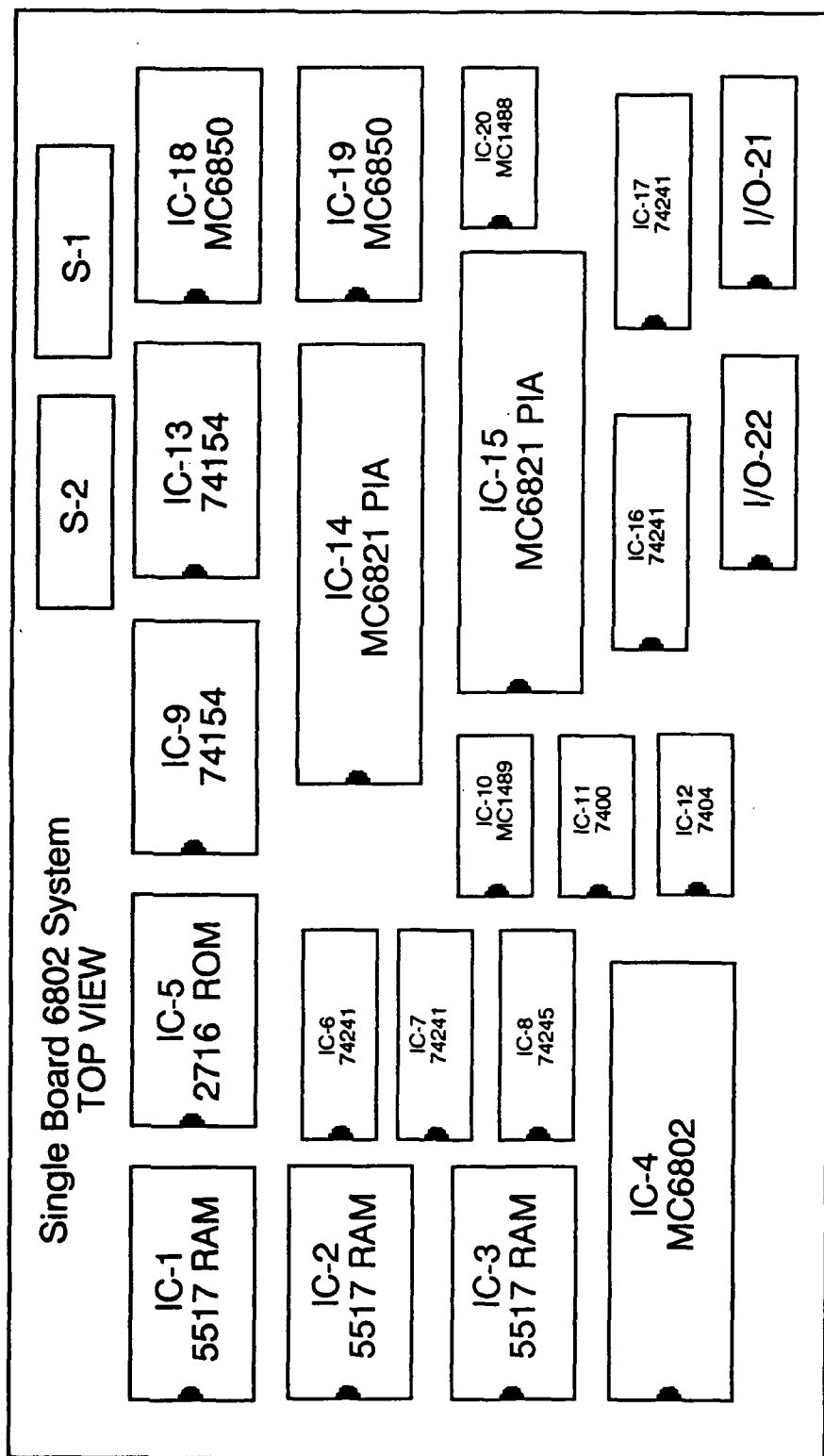
Only seven of the thirty-two 2K memory blocks defined by the address decoders are used in the design shown. It would have been possible to save one chip and decode into eight 8K memory blocks. Use seven of these and allow echoing through the full 8K on each. However, a good base design should have several unused chip selects decoded. This allows a clock or an A to D converter or more memory or more I/O to be added at a later date with almost no more effort than if they had been implemented initially. Without unused chip selects, adding function is a major hassle.

#### MEMORY MAP OF THE SINGLE BOARD MICROPROCESSOR SYSTEM

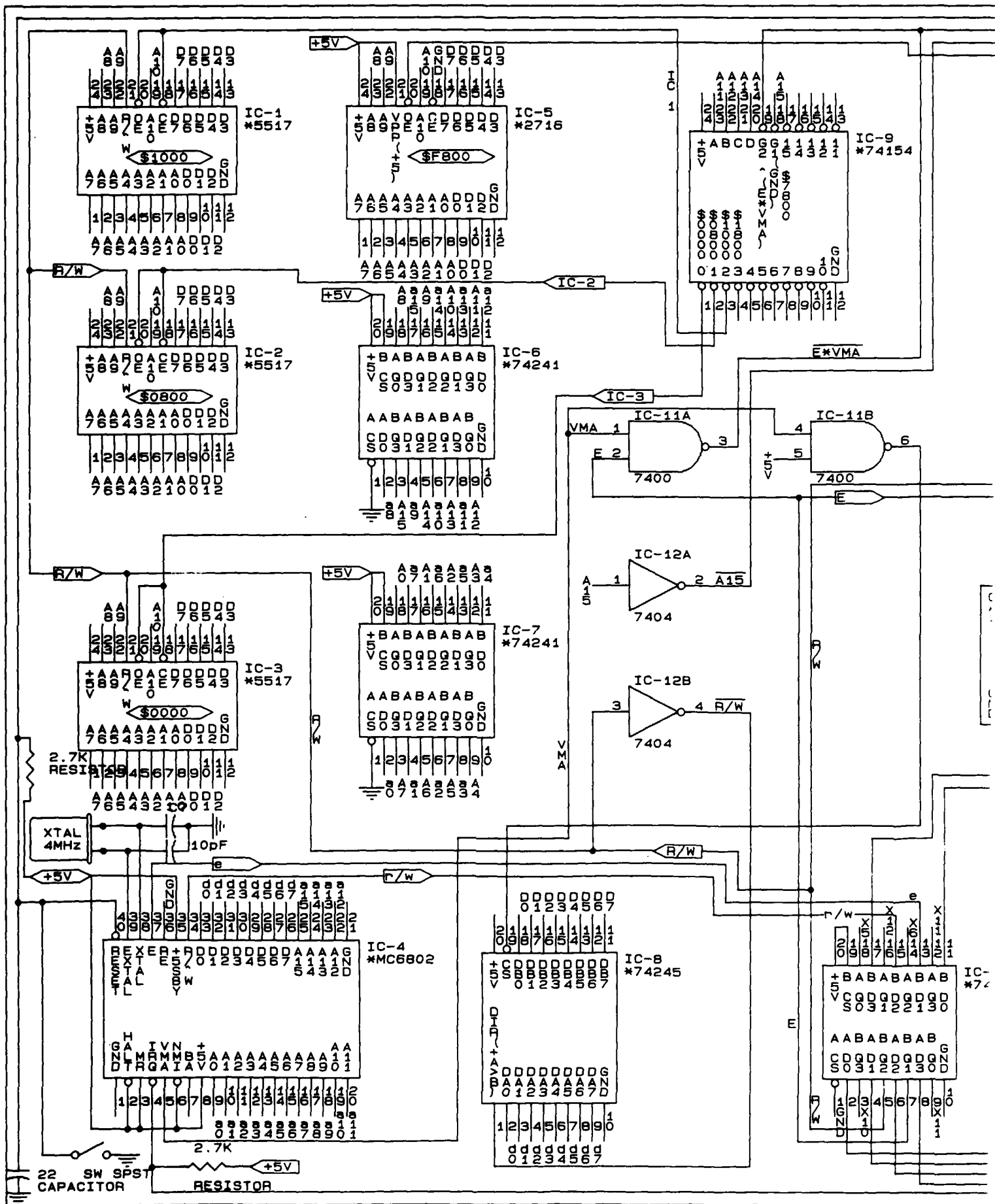
\$FFFF		
\$F800	IC-5	ROM 3K BY 8
\$F000	UNUSED	PIN-16 IC-3
\$E800	IC-18	MC6850 ACIA
\$E000	IC-14	MC6821 PIA
\$D800	IC-15	MC6821 PIA
\$D000	UNUSED	PIN-11 IC-13
\$C800	UNUSED	PIN-10 IC-13
\$C000	UNUSED	PIN-9 IC-13
\$B800	UNUSED	PIN-8 IC-13
\$B000	UNUSED	PIN-7 IC-13
\$A800	UNUSED	PIN-6 IC-13
\$A000	UNUSED	PIN-5 IC-13
\$9800	UNUSED	PIN-4 IC-13
\$9000	UNUSED	PIN-3 IC-13
\$8800	UNUSED	PIN-2 IC-13
\$8000	UNUSED	PIN-1 IC-13
\$7800	UNUSED	PIN-17 IC-9
\$7000	UNUSED	PIN-16 IC-9

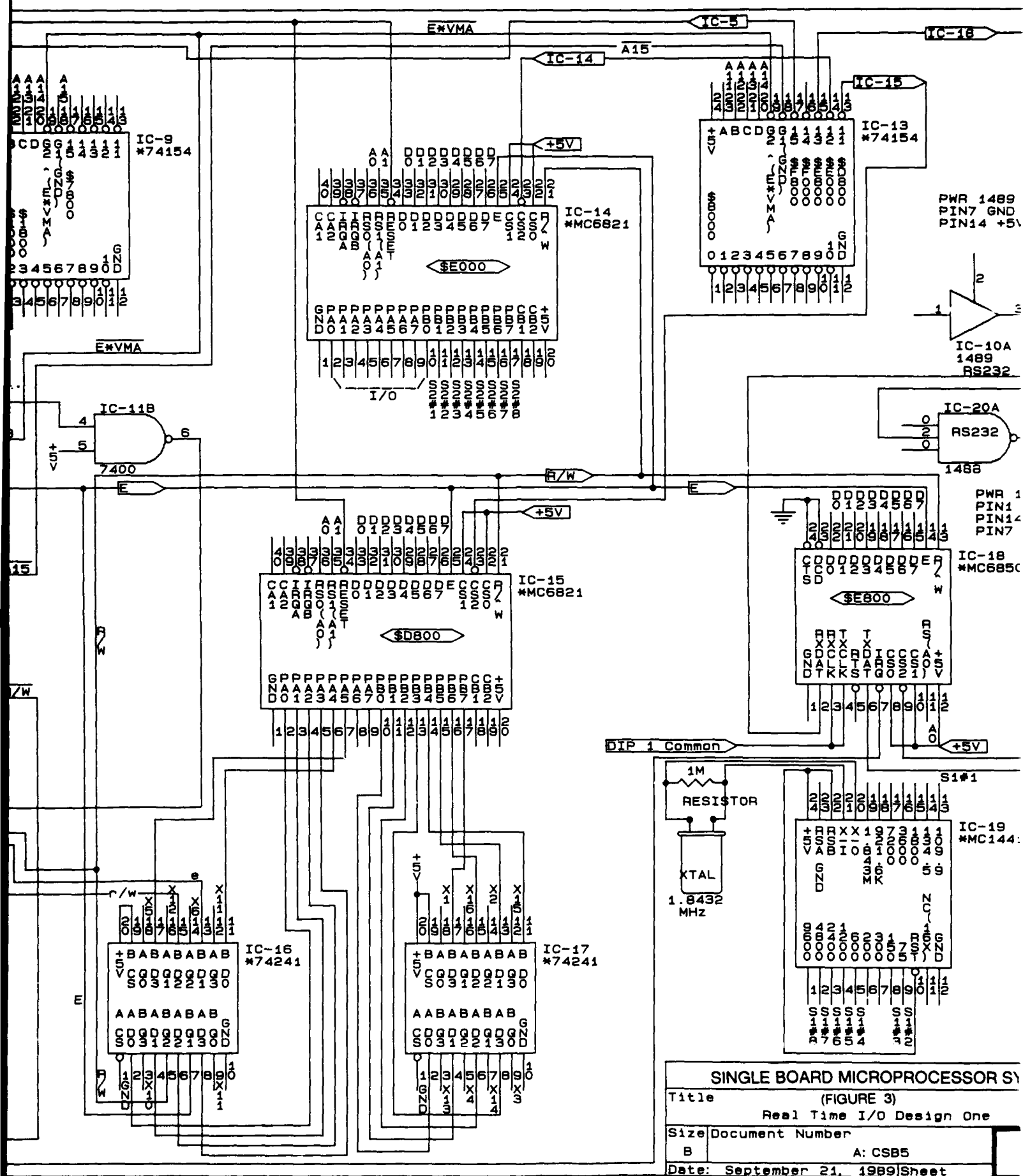


\$6800	UNUSED	PIN-15	IC-9
\$6000	UNUSED	PIN-14	IC-9
\$5800	UNUSED	PIN-13	IC-9
\$5000	UNUSED	PIN-11	IC-9
\$4800	UNUSED	PIN-10	IC-9
\$4000	UNUSED	PIN-9	IC-9
\$3800	UNUSED	PIN-8	IC-9
\$3000	UNUSED	PIN-7	IC-9
\$2800	UNUSED	PIN-6	IC-9
\$2000	UNUSED	PIN-5	IC-9
\$1800	UNUSED	PIN-4	IC-9
\$1000	IC-1	5517	2K BY 8 SRAM
\$0800	IC-2	5517	2K BY 8 SRAM
\$0000	IC-3	5517	2K BY 8 SRAM



(FIGURE 2)





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THE FOLLOWING ASSEMBLY LANGUAGE PROGRAMS WERE WRITTEN FOR THE SINGLE BOARD 6802 MICROPROCESSOR SYSTEM DESCRIBED IN THIS REPORT. ALTHOUGH MOST WERE CREATED SPECIFICALLY FOR THE PROBLEMS FOUND ON THIS PARTICULAR BOARD, THEY SHOULD BE SUFFICIENTLY GENERAL TO PROVIDE INSIGHT INTO THE METHODOLOGY OF TROUBLESHOOTING AND OPERATING THIS TYPE OF SYSTEM.

DOWN AND DOWNROM ARE ASSEMBLY LANGUAGE PROGRAMS WHICH RUN IN THE SS50 6800 SYSTEM AND THE SINGLE BOARD 6802 SYSTEM RESPECTIVELY. THESE ALLOW PROGRAMS TO BE ASSEMBLED IN THE SS50 SYSTEM AND THEN TRANSFERRED TO AND RUN IN THE SINGLE BOARD SYSTEM. THIS ALLOWS SOFTWARE TO BE DEVELOPED FOR THE SINGLE BOARD SYSTEM WITHOUT HAVING TO BURN A NEW EPROM EVERY TIME.

TST13 IS A DATA TRANSFER PROGRAM WHICH ALLOWS DATA TO BE TRANSFERRED FROM A MICROPROCESSOR SYSTEM TO A PC(AT) VIA RS-232-C.

INITIAL TEST PROGRAMS WERE WRITTEN DIRECTLY INTO A 2716 (2K BY 8 EPROM DECODED AT \$F800-\$FFFF) WITH THE RESTART VECTOR AT \$FFFE AND \$FFFF POINTING TO \$F800. INITIAL TEST PROGRAMS SHOULD BE LOOP TYPE PROGRAMS WITH AS FEW STEPS AS POSSIBLE. THE LOOP SHOULD ACCESS A SINGLE DEVICE WITH A SINGLE READ OR WRITE. THIS ALLOWS THE SCOPE TO USE CHIP SELECT AS A SYNC INPUT AND GIVE AS BRIGHT A DISPLAY AS POSSIBLE.

TESTS WERE CONDUCTED WITH THE MINIMUM NUMBER OF INTEGRATED CIRCUITS INSTALLED IN THE BOARD. ALL POWER AND GROUND CONNECTIONS WERE CHECKED ON THE SOCKETS BEFORE THE INTEGRATED CIRCUITS WERE INSTALLED.

NAM TST1

\* THIS PROGRAM LOADS THE A ACCUMULATOR WITH  
\* A CAPITAL "A" (\$41) AND STORES THIS IN  
\* MEMORY LOCATION \$0000. THEN LOOPS BACK TO  
\* THE STORE IN \$0000 ENDLESSLY.

OBJECT CODE: 86 41 \*THIS LOADS THE A  
                  \*ACCUMULATOR WITH "A"  
                  97 00 \*THIS STORES THE A  
                  \*ACCUMULATOR IN \$0000  
                  20 FD \*THIS LOOPS BACK ONE  
                  \*LINE TO 97 00

WITH SCOPE SYNC ON THE CHIP SELECT LINE GOING TO  
MEMORY LOCATION \$0000, IT APPEARED THAT \$FF WAS BEING  
WRITTEN INTO \$0000. THE EXPECTED VALUE OF \$41 WAS NOT  
BEING WRITTEN.

\*\*\*\*\*

NAM TST2

THIS PROGRAM WAS ASSEMBLED TO SEE WHAT  
CODE WOULD EMULATE THE CONDITION OF ALL  
DATA LINES TIED HIGH (+ 5 V) ON INPUT TO  
THE MICROPROCESSOR. THIS WAS DONE BECAUSE  
THE SCOPE HAD SHOWN THE INPUT DATA LINES  
HIGH ALMOST ALL OF THE TIME WHEN ATTEMPTING  
TO RUN TST1.

	OPT	O,S
0100	ORG	\$100
	*	
0100 FF FFFF	STX	\$FFFF
0103 FF FFFF	STX	\$FFFF
	END	

TOTAL ERRORS 00000

STORE THE INDEX REGISTER EXTENDED IN \$FFFF FITS THE BILL. THIS PROGRAM WILL STORE THE FIRST HALF OF WHAT IS IN THE INDEX REGISTER IN MEMORY LOCATION \$FFFF AND STORE THE SECOND HALF OF WHAT IS IN THE INDEX REGISTER IN MEMORY LOCATION \$0000.

THIS SHOULD GIVE ALTERNATING CHIP SELECTS TO IC-3 AND IC-5 (WITH THE R/W LINE LOW). IN FACT, THE SCOPE SHOWED ALTERNATING CHIP SELECTS OF IC-3 AND IC-5 IN THE WRITE MODE .

BASED ON THESE RESULTS ALL CONNECTIONS WERE TRACED OUT ON THE DATA LINES IN QUESTION. THE WIRING APPEARED CORRECT. THE NEXT THING WAS TO REPLACE THE 74245 BIDIRECTIONAL DATA DRIVER CHIP. TST1 NOW RAN CORRECTLY.

\*\*\*\*\*

NAM TST3

CONTINUALLY WRITES THE A ACCUMULATOR (WHATEVER HAPPENS TO BE IN THE A ACCUMULATOR) TO MEMORY LOCATION \$0001

		OPT	O,S
0800		ORG	\$800
	*		
0800 97 01	LP1	STA A	1
0802 20 FC		BRA	LP1
		END	
LP1	0800		

TOTAL ERRORS 00000



THIS PROGRAM APPEARED TO RUN CORRECTLY  
WITH OCCASIONAL BURSTS OF ERRATIC BEHAVIOR.  
PART OF THE TIME THE PROGRAM OPERATED AS  
EXPECTED WITH THE PROPER NUMBER OF CLOCK  
CYCLES PER LOOP. PART OF THE TIME IT WOULD  
RUN IN A LOOP WITH PERHAPS THREE OR FOUR  
TIMES THE NUMBER OF CYCLES EXPECTED IN  
THE LOOP AND WHAT WAS BEING DONE IN THE  
LOOP WAS NOT OBVIOUS.

\*\*\*\*\*

NAM TST4  
(LATER RENAMED DOWNROM)

\*

0800 NAM DOWNROM  
OPT O,S,NOP  
ORG \$0800

THIS PROGRAM RESIDES IN ROM ON  
THE SINGLE BOARD 6802 MICROPROCESSOR THIS  
PROGRAM DOWNLOADS (RECEIVES) AND THEN  
EXECUTES A PROGRAM SENT FROM ANOTHER  
COMPUTER.

IT WAITS UNTIL IT RECEIVES A\$55 IN THE  
ACIA INPUT DATA (AS A SIGNAL) AND:

USES THE NEXT TWO BYTES TO TELL WHERE  
IN MEMORY TO START PUTTING THE PROGRAM

USES THE NEXT TWO BYTES TO TELL HOW  
MANY BYTES TO DOWN LOAD INTO MEMORY

USES THE NEXT TWO BYTES TO TELL WHERE  
IN MEMORY TO EXECUTE THE PROGRAM WHEN  
FINISHED DOWNLOADING

```

      *
      E801  ACRD  EQU  $E801
      E800  ACSR  EQU  $E800
      E800  ACCR  EQU  $E800
      0000  START EQU  0
      0002  QUIT  EQU  2
      0004  EX    EQU  4
      F000  E     EQU  $F000
      *
0800 8E 17FF          LDS  #$17FF
      *
0803 86 03          LDA A  #3
0805 B7 E800          STA A  ACCR
0808 86 15          LDA A  #$15      *WAS $9D FIRST
      *              THIS ENABLED REC IRQ ($9D)
080A B7 E800          STA A  ACCR
      *ACIA SETUP
      *
080D B6 E800 MAIN    LDA A  ACSR (THE ACIA STATUS
                                REGISTER)
0810 84 01          AND A  #$01
0812 27 F9          BEQ   MAIN
      *
0814 B6 E801          LDA A  ACRD (THE ACIA DATA REGISTER)
0817 81 55          CMP A  #$55
0819 26 F2          BNE   MAIN
      *
081B BD F851          JSR   INPUT+E
081E 97 00          STA A  START
0820 BD F851          JSR   INPUT+E
0823 97 01          STA A  START+1
0825 BD F851          JSR   INPUT+E
0828 97 02          STA A  QUIT
082A BD F851          JSR   INPUT+E
082D 9B 01          ADD A  START+1
082F 97 03          STA A  QUIT+1
0831 96 02          LDA A  QUIT
0833 99 00          ADC A  START

```

```

0835 97 02          STA A  QUIT
0837 BD F851        JSR     INPUT+E
083A 97 04          STA A  EX
083C BD F851        JSR     INPUT+E
083F 97 05          STA A  EX+1

```

```

      *
0841 DE 00  XFER    LDX     START
0843 BD F851  XF2    JSR     INPUT+E
0846 A7 00          STA A  0,X
0848 08            INX
0849 9C 02          CPX     QUIT
084B 26 F6          BNE     XF2

```

```

      *
084D DE 04          LDX     EX
084F 6E 00          JMP     0,X

```

```

      *
0851 B6 E800 INPUT  LDA A  ACSR
0854 84 01          AND A  #$01
0856 27 F9          BEQ     INPUT
0858 B6 E801        LDA A  ACRD
085B 39            RTS

```

END

```

ACRD   E801
ACSR   E800
ACCR   E800
START  0000
QUIT   0002
EX      0004
E       F000
MAIN   080D
XFER   0841
XF2    0843
INPUT  0851

```

TOTAL ERRORS 00000

\*\*\*\*\*

	NAM	DOWN
	OPT	O,S
2000	ORG	\$2000

THIS PROGRAM RUNS IN SS50 6800 SYSTEM  
AND DOWNLOADS (TRANSMITS) TO THE SINGLE  
BOARD 6802 MICROPROCESSOR SYSTEM (PROGRAMS  
WHICH THE 6802 SYSTEM WILL RUN)

LOCATIONS \$1000,1001 CONTAIN THE  
STARTING ADDRESS OF DESTINATION PROGRAM IN  
THE 6802 SYSTEM

LOCATIONS \$1002,1003 INDICATE THE  
NUMBER OF BYTES TO BE TRANSFERED

LOCATIONS \$1004,1005 CONTAIN THE  
TRANSFER ADDRESS FOR THE DESTINATION  
PROGRAM (WHERE TO EXECUTE THE PROGRAM IN  
THE SINGLE BOARD 6802 SYSTEM)

LOCATIONS \$1006,1007 HAVE THE STARTING  
ADDRESS OF THE PROGRAM IN SS50 6800 SYSTEM

LOCATIONS \$1008,1009 CONTAIN THE  
ENDING ADDRESS+1 OF THE PROGRAM IN THE SS50  
6800 SYSTEM

	E1D1	OUT1	EQU	\$E1D1
	1006	START	EQU	\$1006
	1008	STOP	EQU	\$1008
2000	86 55	STARD	LDA A	#\$55
2002	BD 203A		JSR	OUT
		*		
2005	B6 1000		LDA A	\$1000
2008	BD 203A		JSR	OUT
200B	B6 1001		LDA A	\$1001

```

200E BD 203A      JSR      OUT
                *
2011 B6 1002      LDA A    $1002
2014 BD 203A      JSR      OUT
2017 B6 1003      LDA A    $1003
201A BD 203A      JSR      OUT
                *
201D B6 1004      LDA A    $1004
2020 BD 203A      JSR      OUT
2023 B6 1005      LDA A    $1005
2026 BD 203A      JSR      OUT
                *
2029 FE 1006      LDX      START
202C A6 00      LP1      LDA A    0,X
202E BD 203A      JSR      OUT
2031 08          INX
2032 BC 1008      CPX      STOP
2035 26 F5      BNE      LP1
                *
2037 7E 7103      JMP      $7103
                *
203A BD E1D1 OUT   JSR      OUT1
203D 86 FF          LDA A    #$FF
203F 4A          DLY2      DEC A
2040 26 FD          BNE      DLY2
2042 39          RTS

```

END

```

OUT1    E1D1
START   1006
STOP    1008
STARD   2000
LP1     202C
OUT     203A
DLY2    203F

```

TOTAL ERRORS 00000

\*\*\*\*\*

NAM TST5

\*  
\*

TST5 CHECKS IF SECTION ONE OF S2 IS  
ON OR OFF.

IF THE BIT IS ON, AN A(\$41) IS PUT OUT  
ON THE A SIDE OF IC14(PIA).

IF THE BIT IS OFF, THEN A B(\$42) IS  
PUT OUT.

THE PROGRAM RUNS IN AN ENDLESS LOOP,  
CONTINUOUSLY CHECKING SECTION 1 OF S2 WHICH  
IS CONNECTED TO PB0 OF IC14(PIA) AT \$E000.

GET ASSEMBLED PROGRAM, RUN <DOWN> TO  
TRANSFER THE OBJECT CODE TO THE  
MICROPROCESSOR.

\*  
\*

```
0100          OPT      O,S,NOP
              ORG      $0100
              * CONSTANT DECLARATIONS
E000          PRA      EQU      $E000      * DDR IF CR(2) IS 0
E001          CRA      EQU      $E001
E002          PRB      EQU      $E002      * DDR IF CR(2) IS 0
E003          CRB      EQU      $E003
1000          WHERE    EQU      $1000      * WHERE STORED ON
                                      BOARD
1000          EXEC     EQU      $1000      * WHERE EXECUTED ON
                                      BOARD
              * PIA INITIALIZATIONS
0100 86 FF    START   LDA A   #$FF
0102 B7 E000          STA A   PRA      * SET A SIDE FOR
                                      OUTPUT ON ALL
                                      LINES
```

```

0105 86 04          LDA A  #$04
0107 B7 E001        STA A  CRA      * ACCESS PERIPHERAL
                                   REGISTER
010A B7 E003        STA A  CRB      * ACCESS PRB

```

\* MAIN LOOP

```

010D B6 E002 LP1    LDA A  PRB
0110 84 01          AND A  #$01
0112 27 07          BEQ    AR1
0114 86 41          LDA A  #$41
0116 B7 E000        STA A  PRA
0119 20 F2          BRA    LP1
011B 86 42 AR1      LDA A  #$42
011D B7 E000        STA A  PRA
0120 20 EB          BRA    LP1

```

\* END MAIN LOOP

\*VARIABLE DECLARATIONS

```

0122 0001          NEXT   RMB      1
          0022          LENG   EQU   NEXT-START
1000                                ORG   $1000
1000 1000          FDB   WHERE
1002 0022          FDB   LENG
1004 1000          FDB   EXEC
1006 0100          FDB   START
1008 0122          FDB   NEXT
                                END

```

```

PRA      E000
CRA      E001
PRB      E002
CRB      E003
WHERE    1000
EXEC     1000
START    0100
LP1      010D
AR1      011B

```

NEXT 0122  
LENG 0022

TOTAL ERRORS 00000

\*\*\*\*\*

NAM TST6

\*

\*

THE PROGRAM TST6 CHECKS TO SEE  
IF SECTION1 OF S2 IS SET OR NOT.

IF IT IS SET, THE HEX VALUE  
CORRESPONDING TO THE DIP SWITCH SETTINGS OF  
S2 IS PUT OUT OVER THE ACIA AND SENT TO  
SECTION A OF THE PIA.

IF SECTION1 OF S2 IS NOT SET,  
A B(\$42) IS SENT TO SECTION A OF THE PIA.

THE PROGRAM RUNS IN AN ENDLESS LOOP  
CONTINUOUSLY CHECKING S2 SECTION 1 WHICH IS  
CONNECTED TO PB0 OF IC14 (PIA) AT \$E000.

AFTER GETTING THE ASSEMBLED PROGRAM,  
RUN <DOWN> TO TRANSFER THE OBJECT CODE  
TO THE MICROPROCESSOR.

0100 OPT O,S  
ORG \$0100

\* CONSTANT DECLARATIONS

E000	PRA	EQU	\$E000	* DDR IF CR(2) IS 0
E001	CRA	EQU	\$E001	
E002	PRB	EQU	\$E002	* DDR IF CR(2) IS 0
E003	CRB	EQU	\$E003	
E801	ACRD	EQU	\$E801	



E800	ACSR	EQU	\$E800	
1000	WHERE	EQU	\$1000	* WHERE STORED ON BOARD
1000	EXEC	EQU	\$1000	* WHERE EXECUTED ON BOARD

\* PIA INITIALIZATIONS

0100	86	FF	START	LDA A	#\$FF	
0102	B7	E000		STA A	PRA	* SET A SIDE FOR OUTPUT
0105	86	04		LDA A	#\$04	
0107	B7	E001		STA A	CRA	* ACCESS PERIPHERAL REGISTER
010A	B7	E003		STA A	CRB	* ACCESSES PRB

\* MAIN LOOP

010D	B6	E002	LP1	LDA A	PRB	
0110	84	01		AND A	#\$01	
0112	27	12		BEQ	AR1	
0114	B6	E002		LDA A	PRB	
0117	B7	E000		STA A	PRA	
*						
011A	F6	E800	LP2	LDA B	ACSR	
011D	C4	02		AND B	#\$02	
011F	27	F9		BEQ	LP2	
0121	B7	E801		STA A	ACRD	
*						
0124	20	E7		BRA	LP1	
0126	86	42	AR1	LDA A	#\$42	
0128	B7	E000		STA A	PRA	
012B	20	E0		BRA	LP1	

\* END MAIN LOOP

\*VARIABLE DECLARATIONS

012D	0001	NEXT	RMB	1
------	------	------	-----	---

	002D	LENG	EQU	NEXT-START
1000			ORG	\$1000
1000	1000		FDB	WHERE
1002	002D		FDB	LENG
1004	1000		FDB	EXEC
1006	0100		FDB	START
1008	012D		FDB	NEXT
			END	

PRA	E000
CRA	E001
PRB	E002
CRB	E003
ACRD	E801
ACSR	E800
WHERE	1000
EXEC	1000
START	0100
LP1	010D
LP2	011A
AR1	0126
NEXT	012D
LENG	002D

TOTAL ERRORS 00000

\*\*\*\*\*

NAM TST7

\*  
\*

THE PROGRAM TST7 CHECKS SECTION 1  
OF SWITCH TWO (S2).

IF THE BIT IS SET, THE HEX VALUES FOR  
0-9 ARE CONTINUOUSLY OUTPUT TO THE ACIA.

IF THE BIT IS NOT SET, A B(\$42) IS  
OUTPUT TO SECTION A OF THE PIA.

THE PROGRAM RUNS IN AN ENDLESS LOOP,  
CONTINUOUSLY CHECKING SECTION 1 OF S2 WHICH  
IS CONNECTED TO PB0 OF IC14 (PIA) ADDRESSED  
AT MEMORY LOCATION \$E000.

AFTER GETTING THE ASSEMBLED PROGRAM,  
RUN <DOWN> TO TRANSFER THE OBJECT CODE TO  
THE MICROPROCESSOR.

```

                                OPT    O,S,NOP
                                ORG    $0100
0100

* CONSTANT DECLARATIONS

E000    PRA    EQU    $E000    * DDR IF CR(2) IS 0
E001    CRA    EQU    $E001
E002    PRB    EQU    $E002    * DDR IF CR(2) IS 0
E003    CRB    EQU    $E003
E801    ACRD   EQU    $E801
E800    ACSR   EQU    $E800
1000    WHERE  EQU    $1000    * WHERE STORED ON
                                BOARD
1000    EXEC   EQU    $1000    * WHERE EXECUTED ON
                                BOARD

* PIA INITIALIZATIONS

0100 86 FF    START LDA A    #$FF
0102 B7 E000          STA A    PRA    * SET A SIDE FOR
                                OUTPUT
0105 86 04          LDA A    #$04
0107 B7 E001          STA A    CRA    * ACCESS PERIPHERAL
                                REGISTER
010A B7 E003          STA A    CRB    * ACCESSES PRB

* MAIN LOOP

010D 30    NUM    FCB    $30

```

```

010E B6 E002 LP1      LDA A  PRB
0111 84 01            AND A  #$01
0113 27 1F            BEQ    AR1
                    * LDAA PRB
                    * STAA PRA
0115 B6 010D          LDA A  NUM
                    *
0118 F6 E800 LP2      LDA B  ACSR
011B C4 02            AND B  #$02
011D 27 F9            BEQ    LP2
011F B7 E801          STA A  ACRD
                    *INC NUM COMP TO 39
0122 B6 010D          LDA A  NUM
0125 4C              INC A
0126 B7 010D          STA A  NUM
0129 81 3A            CMP A  #$3A
012B 26 05            BNE    AR4
012D 86 30            LDA A  #$30
012F B7 010D          STA A  NUM
                    *
0132 20 DA  AR4      BRA     LP1
0134 86 42  AR1      LDA A  #$42
0136 B7 E000        STA A  PRA
0139 20 D3          BRA     LP1

* END MAIN LOOP

*VARIABLE DECLARATIONS

013B 0001  NEXT      RMB      1
      003B  LENG      EQU     NEXT-START
1000      ORG      $1000
1000 1000      FDB      WHERE
1002 003B      FDB      LENG
1004 1000      FDB      EXEC
1006 0100      FDB      START
1008 013B      FDB      NEXT
      END

```

PRA	E000
CRA	E001
PRB	E002
CRB	E003
ACRD	E801
ACSR	E800
WHERE	1000
EXEC	1000
START	0100
NUM	010D
LP1	010E
LP2	0118
AR4	0132
AR1	0134
NEXT	013B
LENG	003B

TOTAL ERRORS 00000

\*\*\*\*\*

NAM TST8

\*

PURPOSE: THE PROGRAM TST8 PUTS OUT  
NUMBERS 0-9 , CR, LF AND HAS A TIME DELAY  
SO THAT THERE IS NO DATA LOSS WHEN  
TRANSFERRING TO AN IBM PC(AT).

GET THE ASSEMBLED PROGRAM, RUN <DOWN>  
TO TRANSFER THE OBJECT CODE TO THE  
MICROPROCESSOR.

0100	OPT	O,S,NOP
	ORG	\$0100

\* CONSTANT DECLARATIONS

0F00	E	EQU	\$F00	*ASMB AT \$0100 TO RUN AT \$100
E000	PRA	EQU	\$E000	*(DDR) IF CR(2) IS 0
E001	CRA	EQU	\$E001	
E002	PRB	EQU	\$E002	* DDR IF CR(2) IS 0
E003	CRB	EQU	\$E003	
E801	ACDR	EQU	\$E801	
E800	ACSR	EQU	\$E800	
1000	WHERE	EQU	\$1000	* WHERE STORED ON BOARD
1000	EXEC	EQU	\$1000	* WHERE EXECUTED ON BOARD
E002	SW2	EQU	\$E002	* DIP SWITCH 2 USED FOR INPUT

\*

\* PIA INITIALIZATIONS

0100 86 FF	START	LDA A	#\$FF	
0102 B7 E000		STA A	PRA	* SET A SIDE FOR OUTPUT
0105 86 04		LDA A	#\$04	
0107 B7 E001		STA A	CRA	* ACCESS PERIPHERAL REGISTER
010A B7 E003		STA A	CRB	* ACCESSES PRB

\*

\* MAIN LOOP

\*

010D B6 E002	LP1	LDA A	PRB
0110 85 01		BIT A	#\$01
0112 27 F9		BEQ	LP1
0114 B6 0156		LDA A	NUM
0117 BD 1031		JSR	OUTA+E
011A 7C 0156		INC	NUM
011D 81 39		CMP A	#\$39
011F 26 EC		BNE	LP1
0121 BD 104B		JSR	CRLF+E
0124 86 30		LDA A	#\$30

```

0126 B7 0156      STA A  NUM
0129 CE 2000      LDX   #$2000
012C BD 1047      JSR   DLY1+E
012F 20 DC        BRA   LP1

```

```

*
*  END MAIN LOOP
*

```

OUTA PUTS OUT ON THE ACIA WHAT IS IN THE A ACCUMULATOR, DESTROYS THE B ACCUMULATOR, RETURNS NOTHING, AND PRESERVES THE INDEX REGISTER

```

0131 F6 E800 OUTA  LDA B  ACSR
0134 C5 02         BIT B  #$02
0136 27 F9         BEQ   OUTA
0138 B7 E801      STA A  ACDR
013B 39           RTS

```

INA INPUTS A CHARACTER FROM THE ACIA INTO THE A ACCUMULATOR, PRESERVES THE B ACCUMULATOR, AND PRESERVES THE INDEX REGISTER

```

013C F6 E800 INA   LDA B  ACSR
013F C4 01         AND B  #$01
0141 27 F9         BEQ   INA
0143 B6 E801      LDA A  ACDR
0146 39           RTS

```

DLY1 TAKES WHAT IS IN THE X REGISTER AND DECREASES IT TO ZERO CREATING A TIME DELAY AND DESTROYING WHATS IN THE INDEX REGISTER

```

0147 09          DLY1  DEX
0148 26 FD        BNE   DLY1
014A 39          RTS

```

# CRLF PUTS OUT CARRIAGE RETURN & LINE FEED

TO ACIA

014B	86	0D	CRLF	LDA	A	#\$0D
014D	BD	1031		JSR		OUTA+E
0150	86	0A		LDA	A	#\$0A
0152	BD	1031		JSR		OUTA+E
0155	39			RTS		

## VARIABLE DECLARATIONS

0156	30	NUM	FCB	\$30
0157	07	CNT2	FCB	\$7
0158	0001	NEXT	RMB	1
	0058	LENG	EQU	NEXT-START
1000			ORG	\$1000
1000	1000		FDB	WHERE
1002	0058		FDB	LENG
1004	1000		FDB	EXEC
1006	0100		FDB	START
1008	0158		FDB	NEXT

\*

END

E	0F00
PRA	E000
CRA	E001
PRB	E002
CRB	E003
ACDR	E801
ACSR	E800
WHERE	1000
EXEC	1000
SW2	E002
START	0100
LP1	010D
OUTA	0131
INA	013C
DLY1	0147
CRLF	014B



NUM 0156  
 CNT2 0157  
 NEXT 0158  
 LENG 0058

TOTAL ERRORS 00000

\*\*\*\*\*

NAM TST10

\*

PURPOSE : PUTS OUT 0-9, CR & LF, LINE  
 NUMBERS WITH ENOUGH DELAY SO NO CHARACTERS  
 LOST BY THE PC(AT) ON THE RECEIVING END.

\*\*\*\*\*+PUTS GARBAGE OUT++++\*\*\*\*\*  
 BECAUSE COUNTER NEEDS OFFSET IN MEMORY.

GET THE ASSEMBLED PROGRAM, RUN <DOWN>  
 TO TRANSFER THE OBJECT CODE TO THE  
 MICROPROCESSOR.

0100 OPT O,S,NOP  
 ORG \$0100

# CONSTANT DECLARATIONS

0F00	E	EQU	\$F00	* ASMB AT \$0100 TO RUN AT \$100
E000	PRA	EQU	\$E000	* DDR IF CR(2) IS 0
E001	CRA	EQU	\$E001	
E002	PRB	EQU	\$E002	* DDR IF CR(2) IS 0
E003	CRB	EQU	\$E003	
E801	ACDR	EQU	\$E801	
E800	ACSR	EQU	\$E800	
1000	WHERE	EQU	\$1000	* WHERE STORED ON BOARD

1000	EXEC	EQU	\$1000	* WHERE EXECUTED ON BOARD
E002	SW2	EQU	\$E002	* DIP SWITCH 2 USED FOR INPUT
* PIA INITIALIZATIONS				
0100	86 FF	START	LDA A #\$FF	
0102	B7 E000		STA A PRA	* SET A SIDE FOR OUTPUT
0105	86 04		LDA A #\$04	
0107	B7 E001		STA A CRA	* ACCESS THE A PERIPHERAL REGISTER
010A	B7 E003		STA A CRB	* ACCESSES PRB
* MAIN LOOP				
010D	B6 E002	LP1	LDA A PRB	
0110	85 01		BIT A #\$01	
0112	27 F9		BEQ LP1	
0114	B6 016C		LDA A CNT2	* PUT LINE NUMBERS ON LINES
0117	8B 30		ADD A #\$30	
0119	BD 104B		JSR OUTA+E	
011C	86 20		LDA A #\$20	
011E	BD 104B		JSR OUTA+E	
0121	B6 016B	LP2	LDA A CNT1	* PRINT OUT STRING
0124	BD 104B		JSR OUTA+E	
0127	7C 016B		INC CNT1	
012A	81 39		CMP A #\$39	
012C	26 F3		BNE LP2	
012E	BD 1065		JSR CRLF+E	
0131	86 30		LDA A #\$30	
0133	B7 016B		STA A CNT1	
0136	CE 2000		LDX #\$2000	
0139	BD 1061		JSR DLY1+E	
013C	7C 016C		INC CNT2	

013F	F6	016C	LDA	B	CNT2
0142	C1	0A	CMP	B	#\$A
0144	26	C7	BNE		LP1
0146	7F	016C	CLR		CNT2
0149	20	C2	BRA		LP1

\* END MAIN LOOP

OUTA PUTS OUT CN THE ACIA WHAT IS IN THE A ACCUMULATOR, DESTROYS THE B ACCUMULATOR, RETURNS NOTHING, AND PRESERVES THE INDEX REGISTER

014B	F6	E800	OUTA	LDA	B	ACSR
014E	C5	02		BIT	B	#\$02
0150	27	F9		BEQ		OUTA
0152	B7	E801		STA	A	ACDR
0155	39			RTS		

INA INPUTS A CHARACTER FROM THE ACIA INTO THE A ACCUMULATOR, PRESERVES THE B ACCUMULATOR, AND PRESERVES THE INDEX REGISTER

0156	F6	E800	INA	LDA	B	ACSR
0159	C4	01		AND	B	#\$01
015B	27	F9		BEQ		INA
015D	B6	E801		LDA	A	ACDR
0160	39			RTS		

DLY1 TAKES WHAT IS IN THE INDEX REGISTER AND DECREMENTS IT TO ZERO CREATING A TIME DELAY AND DESTROYING WHATS IN THE INDEX REGISTER

0161	09		DLY1	DEX	
0162	26	FD		BNE	DLY1
0164	39			RTS	

CRLF PUTS OUT CARRIAGE RETURN & LINE  
FEED

ONLY PUTS OUT CARRIAGE RETURN BECAUSE  
PC UNDERSTANDS CARRIAGE RETURN AS CARRIAGE  
RETURN AND LINE FEED.

0165 86 0D CRLF LDA A #\$0D  
0167 BD 104B JSR OUTA+E

\*LDAA #\$0A  
\*JSR OUTA+E

016A 39 RTS

\*  
\*VARIABLE DECLARATIONS

016B 30 CNT1 FCB \$30  
016C 00 CNT2 FCB \$0  
016D 0001 NEXT RMB 1  
006D LENG EQU NEXT-START  
1000 ORG \$1000  
1000 1000 FDB WHERE  
1002 006D FDB LENG  
1004 1000 FDB EXEC  
1006 0100 FDB START  
1008 016D FDB NEXT

\*  
END

E 0F00  
PRA E000  
CRA E001  
PRB E002  
CRB E003  
ACDR E801  
ACSR E800  
WHERE 1000  
EXEC 1000  
SW2 E002  
START 0100  
LP1 010D

LP2 0121  
OUTA 014B  
INA 0156  
DLY1 0161  
CRLF 0165  
CNT1 016B  
CNT2 016C  
NEXT 016D  
LENG 006D

TOTAL ERRORS 00000

\*\*\*\*\*

NAM TST12

PURPOSE OF PROGRAM : SEND STRING OF  
CHARACTERS TO PC WITH LINE NUMBERS.

METHOD :

CHECK SWITCH \*\* OUTPUT <CR>AAA<CR>

PUT LINE NUMBERS ON LINES

PRINT STRING

REINITIALIZE CHAR COUNT TO 0

DELAY #\$2000

INCREMENT LINE NUMBER

CHECK SWITCH, BRANCH IF STILL ON

OUTPUT BBB SO PC KNOWS IT IS THE END OF  
TRANSFER

DELAY #\$FFFF

BACK TO BEGINNING, WAIT FOR SWITCH

GET ASSEMBLED PROGRAM, RUN <DOWN>  
TO TRANSFER THE OBJECT CODE TO THE  
MICROPROCESSOR.

```

                                OPT    O,S,NOP
                                ORG     $0100
0100      * CONSTANT DECLARATIONS

                                OF00    E      EQU     $F00      * ASMB AT $0100 RUN
                                                AT $1000
                                E000    PRA     EQU     $E000      * DDR IF CR(2) IS 0
                                E001    CRA     EQU     $E001
                                E002    PRB     EQU     $E002      * DDR IF CR(2) IS 0
                                E003    CRB     EQU     $E003
                                E801    ACDR    EQU     $E801
                                E800    ACSR    EQU     $E800
                                1000    WHERE  EQU     $1000      * WHERE STORED ON
                                                BOARD
                                1000    EXEC    EQU     $1000      * WHERE EXECUTED ON
                                                BOARD
                                E002    SW2     EQU     $E002      * DIP SWITCH 2 USED
                                                FOR CONTROL INPUT
                                *
                                * PIA INITIALIZATIONS

0100 86 FF  START  LDA A  #$FF
0102 B7 E000      STA A  PRA      * SET A SIDE FOR
                                                OUTPUT

                                0105 86 04      LDA A  #$04
                                0107 B7 E001      STA A  CRA      * ACCESS PERIPHERAL
                                                REGISTER
                                010A B7 E003      STA A  CRB      * ACCESSES PRB
                                *

```

```

* MAIN LOOP
*
010D B6 E002 LP      LDA A  PRB      * CHECK SWITCH
0110 85 01          BIT A  #$01
0112 27 F9          BEQ    LP
0114 86 0D          LDA A  #$0D
0116 BD 1083        JSR    OUTA+E
0119 86 41          LDA A  #$41
011B BD 1083        JSR    OUTA+E
011E BD 1083        JSR    OUTA+E
0121 BD 1083        JSR    OUTA+E
0124 86 0D          LDA A  #$0D
0126 BD 1083        JSR    OUTA+E
*
0129 B6 10A4 LP1    LDA A  CNT2+E    * PUT LINE NUMBERS
                                ON LINES
012C 8B 30          ADD A  #$30
012E BD 1083        JSR    OUTA+E
0131 86 20          LDA A  #$20
0133 BD 1083        JSR    OUTA+E
0136 B6 10A3 LP2    LDA A  CNT1+E    * PRINT OUT STRING
0139 BD 1083        JSR    OUTA+E
013C 7C 10A3        INC    CNT1+E
013F 81 39          CMP A  #$39
0141 26 F3          BNE    LP2
0143 BD 109D        JSR    CRLF+E
0146 86 30          LDA A  #$30      * REINITIALIZE COUNT
                                TO 0
0148 B7 10A3        STA A  CNT1+E
014B CE 2000        LDX    #$2000
014E BD 1099        JSR    DLY1+E
0151 7C 10A4        INC    CNT2+E    * INCREMENT LINE
                                NUMBER
0154 F6 10A4        LDA B  CNT2+E
0157 C1 0A          CMP B  #$A
0159 26 CE          BNE    LP1
015B 7F 10A4        CLR    CNT2+E
015E B6 E002        LDA A  PRB      * CHECK IF SWITCH IS
                                STILL ON

```

0161 85 01	BIT A	#\$01	
0163 26 C4	BNE	LP1	* IF SWITCH ON CHECK AGAIN
0165 86 0D	LDA A	#\$0D	
0167 BD 1083	JSR	OUTA+E	
016A 86 42	LDA A	#\$42	* SEND BBB AT END OF XMIT
016C BD 1083	JSR	OUTA+E	
016F BD 1083	JSR	OUTA+E	
0172 BD 1083	JSR	OUTA+E	
0175 86 0D	LDA A	#\$0D	* CARRIAGE RETURN
0177 BD 1083	JSR	OUTA+E	
017A CE FFFF	LDX	#\$FFFF	* DELAY BEFORE BRANCHING BACK
017D BD 1099	JSR	DLY1+E	
0180 7E 100D	JMP	LP+E	

END MAIN LOOP

OUTA PUTS OUT ON THE ACIA WHAT IS IN THE A ACCUMULATOR, DESTROYS THE B ACCUMULATOR, RETURNS NOTHING AND PRESERVES THE INDEX REGISTER

0183 F6 E800 OUTA	LDA B	ACSR
0186 C5 02	BIT B	#\$02
0188 27 F9	BEQ	OUTA
018A B7 E801	STA A	ACDR
018D 39	RTS	

INA INPUTS A CHARACTER FROM THE ACIA INTO THE A ACCUMULATOR, PRESERVES THE B ACCUMULATOR AND PRESERVES THE INDEX REGISTER

018E F6 E800 INA	LDA B	ACSR
------------------	-------	------



```

0191 C4 01          AND B  #$01
0193 27 F9          BEQ   INA
0195 B6 E801        LDA A  ACDR
0198 39              RTS

```

DLY1 TAKES WHAT IS IN THE INDEX REGISTER AND DECREMENTS IT TO ZERO CREATING A TIME DELAY AND DESTROYING WHAT IS IN THE INDEX REGISTER

```

0199 09          DLY1  DEX
019A 26 FD        BNE   DLY1
019C 39          RTS

```

CRLF PUTS OUT CARRIAGE RETURN & LINE FEED TO ACIA

ONLY PUTS OUT CARRIAGE RETURN BECAUSE PC UNDERSTANDS CARRIAGE RETURN AS CARRIAGE RETURN AND LINE FEED.

```

019D 86 0D        CRLF  LDA A  #$0D
019F BD 1083      JSR   OUTA+E
                  *LDAA #$0A
                  *JSR OUTA+E
01A2 39          RTS

```

\*  
\*VARIABLE DECLARATIONS

```

01A3 30          CNT1  FCB    $30
01A4 00          CNT2  FCB    $0
01A5 0001        NEXT  RMB    1
                00A5    LENG  EQU  NEXT-START
1000              ORG    $1000
1000 1000        FDB    WHERE
1002 00A5        FDB    LENG
1004 1000        FDB    EXEC
1006 0100        FDB    START
1008 01A5        FDB    NEXT

```

\*

END

E 0F00  
PRA E000  
CRA E001  
PRB E002  
CRB E003  
ACDR E801  
ACSR E800  
WHERE 1000  
EXEC 1000  
SW2 E002  
START 0100  
LP 010D  
LP1 0129  
LP2 0136  
OUTA 0183  
INA 018E  
DLY1 0199  
CRLF 019D  
CNT1 01A3  
CNT2 01A4  
NEXT 01A5  
LENG 00A5

TOTAL ERRORS 00000

\*\*\*\*\*

NAM TST13

THIS PROGRAM TRANSFERS ASCII  
CHARACTERS COMING IN ON THE ACIA OUT TO A  
PC(AT) VIA ACIA (RS-232-C)

IT ONLY TRANSFERS DATA IF THE PROPER  
SWITCH IS THROWN

IT DOES NOT TRANSFER NULLS (✓00)

IT DOES NOT TRANSFER LINE FEEDS (\$0A)

GET ASSEMBLED PROGRAM, RUN <DOWN>  
TO TRANSFER THE OBJECT CODE TO THE  
MICROPROCESSOR.

0100                   OPT     O,S,NOP  
                      ORG     \$0100

\* CONSTANT DECLARATIONS

0F00	E	EQU	\$F00	* ASMB AT \$0100 TO RUN \$1000
E000	PRA	EQU	\$E000	* DDR IF CR(2) IS 0
E001	CRA	EQU	\$E001	
E002	PRB	EQU	\$E002	* DDR IF CR(2) IS 0
E003	CRB	EQU	\$E003	
E801	ACDR	EQU	\$E801	
E800	ACSR	EQU	\$E800	
1000	WHERE	EQU	\$1000	* WHERE STORED ON BOARD
1000	EXEC	EQU	\$1000	* WHERE EXECUTED ON BOARD
E002	SW2	EQU	\$E002	* DIP SWITCH 2 USED FOR TRANSMIT CONTROL INPUT

PIA INITIALIZATIONS

0100 86 FF	START	LDA A	#\$FF	
0102 B7 E000		STA A	PRA	* SET A SIDE FOR OUTPUT
0105 86 04		LDA A	#\$04	
0107 B7 E001		STA A	CRA	* ACCESS PERIPHERAL REGISTER A
010A B7 E003		STA A	CRB	* ACCESS PR-B

MAIN LOOP

010D B6 E002 LP	LDA A	PRB	* CHECK SWITCH
-----------------	-------	-----	----------------

```

0110 85 01          BIT A  #$01
0112 27 F9          BEQ    LP

0114 BD 1030 MAIN    JSR    INA+E    * INPUT A CHARACTER
0117 81 00          CMP A  #$00    * CHECK IF CHARACTER
                                IS NULL

0119 27 F9          BEQ    MAIN
011B 81 0A          CMP A  #$A    * IS CHARACTER A
                                LINE FEED

011D 27 F5          BEQ    MAIN
011F BD 1025        JSR    OUTA+E    * OUTPUT A CHARACTER
0122 7E 100D        JMP    LP+E

```

END MAIN LOOP

OUTA PUTS OUT ON THE ACIA WHAT IS IN  
THE A ACCUMULATOR, DESTROYS THE B  
ACCUMULATOR, RETURNS NOTHING, AND PRESERVES  
THE INDEX REGISTER

```

0125 F6 E800 OUTA    LDA B  ACSR
0128 C5 02          BIT B  #$02
012A 27 F9          BEQ    OUTA
012C B7 E801        STA A  ACDR
012F 39            RTS

```

INA INPUTS A CHARACTER FROM THE ACIA  
INTO THE A ACCUMULATOR, PRESERVES THE B  
ACCUMULATOR AND PRESERVES THE INDEX  
REGISTER

```

0130 F6 E800 INA     LDA B  ACSR
0133 C4 01          AND B  #$01
0135 27 F9          BEQ    INA
0137 B6 E801        LDA A  ACDR
013A 39            RTS

```

DLY1 TAKES WHAT IS IN THE INDEX  
REGISTER AND DECREMENTS IT TO ZERO TO  
CREATE A TIME DELAY AND DESTROYS WHAT IS IN  
THE INDEX REGISTER

```
013B 09      DLY1  DEX
013C 26 FD      BNE  DLY1
013E 39      RTS
```

CRLF PUTS OUT CARRIAGE RETURN & LINE  
FEED TO ACIA  
ONLY PUTS OUT CARRIAGE RETURN BECAUSE  
PC UNDERSTANDS CARRIAGE RETURN AS CARRIAGE  
RETURN AND LINE FEED

```
013F 86 0D  CRLF  LDA A  #$0D
0141 BD 1025      JSR  OUTA+E
                *LDAA #$0A          NOT USED
                *JSR OUTA+E          NOT USED
0144 39      RTS
```

#### VARIABLE DECLARATIONS

```
0145 0001  NEXT  RMB    1
          0045  LENG  EQU  NEXT-START
1000      ORG    $1000
1000 1000  FDB    WHERE
1002 0045  FDB    LENG
1004 1000  FDB    EXEC
1006 0100  FDB    START
1008 0145  FDB    NEXT
```

\*

END

```
E      0F00
PRA    E000
CRA    E001
PRB    E002
CRB    E003
ACDR   E801
```

ACSR	E800
WHERE	1000
EXEC	1000
SW2	E002
START	0100
LP	010D
MAIN	0114
OUTA	0125
INA	0130
DLY1	013B
CRLF	013F
NEXT	0145
LENG	0045

TOTAL ERRORS 00000

\*\*\*\*\*

The single board 6802 based microprocessor system was constructed on a Vector 8804 S-100 circuit card. The S-100 edge connector was not used (the connector was sheared off even with the rest of the board). The Vector board is very desirable because it provides a full conductive grid on both the top and bottom of the board. The top grid (component side) is connected to the regulated plus five volt supply. The bottom grid is ground. The system was constructed with wire wrap sockets (three wrap length), and 30 gauge wire wrap wire (modified wrap).

The wire wrap list for this computer system was generated from the schematic diagram on page 13 (figure number 3). The following method was used to create the wire wrap list and check its accuracy:

STARTING WITH PIN-1 IC-1 A WIRE IS TRACED IN RED ON THE SCHEMATIC DIAGRAM, AND LISTED ON THE WIRE WRAP LIST AFTER IC-1 PIN-1.

IF IT GOES TO A WIRE WRAP PIN, AN "X" IS PLACED AFTER THAT PIN ON THE LIST TO INDICATE THAT A WIRE HAS BEEN RUN THERE (BUT IS LISTED ELSEWHERE).

IF MORE WIRES ARE NEEDED FROM IC-1 PIN-1 THEY ARE MARKED IN RED AND LISTED ON THE LIST ALSO.

WHEN DRAWING THE RED LINES ON THE SCHEMATIC DIAGRAM IT HELPS TO PUT HEAD AND TAIL ARROWS ON THE LINE TO SHOW WHICH WAY IT WAS RUN (WHERE IT WOULD BE LISTED ON THE WIRE WRAP LIST).

DO NOT OVERLAP RED LINES TO THE SAME LOCATION (ON THE SCHEMATIC) SO THAT THE INDIVIDUAL WIRE WRAP WIRES MAY BE DISTINGUISHED.

CHECK THE WIRE WRAP LIST BEFORE ACTUAL CONSTRUCTION BY TAKING A FRESH COPY OF THE SCHEMATIC AND PUT IN RED LINES CORRESPONDING TO THE LIST. ANY BARE BLACK LINES REPRESENT ERRORS IN THE LIST.

Two PC programs written in C are included on page seventy one to assist with the construction of wire wrap lists. The first (WWLIST) creates a blank list which is filled in by hand from the schematic. The second (UPDATEWW) allows easy entry of the hand written data (where to information) into a computer file where it can be duplicated or searched conveniently. It is very convenient to have two persons when creating and updating the wire wrap list.

IC 1	Name 5517	Pins 24
( ) ( )	IC 1 -PIN 1 TO IC2 -PIN	1 & IC5 PIN 1
( ) ( )	IC 1 -PIN 2 TO IC2 -PIN	2 & IC5 PIN 2
( ) ( )	IC 1 -PIN 3 TO IC2 -PIN	3 & IC5 PIN 3
( ) ( )	IC 1 -PIN 4 TO IC2 -PIN	4 & IC5 PIN 4
( ) ( )	IC 1 -PIN 5 TO IC2 -PIN	5 & IC5 PIN 5
( ) ( )	IC 1 -PIN 6 TO IC2 -PIN	6 & IC5 PIN 6
( ) ( )	IC 1 -PIN 7 TO IC2 -PIN	7 & IC5 PIN 7
( ) ( )	IC 1 -PIN 8 TO IC2 -PIN	8 & IC5 PIN 8
( ) ( )	IC 1 -PIN 9 TO IC2 -PIN	9 & IC5 PIN 9
( ) ( )	IC 1 -PIN 10 TO IC2 -PIN	10 & IC5 PIN 10
( ) ( )	IC 1 -PIN 11 TO IC2 -PIN	11 & IC5 PIN 11
( ) ( )	IC 1 -PIN 12 TO-----	GND
( ) ( )	IC 1 -PIN 13 TO IC2 -PIN	13 & IC5 PIN 13
( ) ( )	IC 1 -PIN 14 TO IC2 -PIN	14 & IC5 PIN 14
( ) ( )	IC 1 -PIN 15 TO IC2 -PIN	15 & IC5 PIN 15
( ) ( )	IC 1 -PIN 16 TO IC2 -PIN	16 & IC5 PIN 16
( ) ( )	IC 1 -PIN 17 TO IC2 -PIN	17 & IC5 PIN 17
( ) ( )	IC 1 -PIN 18 TO IC1 -PIN	20
( ) ( )	IC 1 -PIN 19 TO IC2 -PIN	19 & IC5 PIN 19
( ) ( )	IC 1 -PIN 20 TO IC9 -PIN	3 X
( ) ( )	IC 1 -PIN 21 TO IC2 -PIN	21
( ) ( )	IC 1 -PIN 22 TO IC2 -PIN	22 & IC5 PIN 22
( ) ( )	IC 1 -PIN 23 TO IC2 -PIN	23 & IC5 PIN 23
( ) ( )	IC 1 -PIN 24 TO -----	+5V



IC 2	Name 5517	Pins 24
( ) ( )	IC 2 -PIN 1 TO IC3 -PIN	1 X
( ) ( )	IC 2 -PIN 2 TO IC3 -PIN	2 X
( ) ( )	IC 2 -PIN 3 TO IC3 -PIN	3 X
( ) ( )	IC 2 -PIN 4 TO IC3 -PIN	4 X
( ) ( )	IC 2 -PIN 5 TO IC3 -PIN	5 X
( ) ( )	IC 2 -PIN 6 TO IC3 -PIN	6 X
( ) ( )	IC 2 -PIN 7 TO IC3 -PIN	7 X
( ) ( )	IC 2 -PIN 8 TO IC3 -PIN	8 X
( ) ( )	IC 2 -PIN 9 TO IC3 -PIN	9 X
( ) ( )	IC 2 -PIN 10 TO IC3 -PIN	10 X
( ) ( )	IC 2 -PIN 11 TO IC3 -PIN	11 X
( ) ( )	IC 2 -PIN 12 TO -----	GND
( ) ( )	IC 2 -PIN 13 TO IC3 -PIN	13 X
( ) ( )	IC 2 -PIN 14 TO IC3 -PIN	14 X
( ) ( )	IC 2 -PIN 15 TO IC3 -PIN	15 X
( ) ( )	IC 2 -PIN 16 TO IC3 -PIN	16 X
( ) ( )	IC 2 -PIN 17 TO IC3 -PIN	17 X
( ) ( )	IC 2 -PIN 18 TO IC2 -PIN	20
( ) ( )	IC 2 -PIN 19 TO IC3 -PIN	19 X
( ) ( )	IC 2 -PIN 20 TO IC9 -PIN	2 X
( ) ( )	IC 2 -PIN 21 TO IC3 -PIN	21 X
( ) ( )	IC 2 -PIN 22 TO IC3 -PIN	22 X
( ) ( )	IC 2 -PIN 23 TO IC3 -PIN	23 X
( ) ( )	IC 2 -PIN 24 TO-----	+5V

IC 3	Name 5517	Pins 24
( ) ( )	IC 3 -PIN 1 TO IC7 -PIN	3 X
( ) ( )	IC 3 -PIN 2 TO IC7 -PIN	5 X
( ) ( )	IC 3 -PIN 3 TO IC7 -PIN	7 X
( ) ( )	IC 3 -PIN 4 TO IC7 -PIN	9 X
( ) ( )	IC 3 -PIN 5 TO IC7 -PIN	12 X
( ) ( )	IC 3 -PIN 6 TO IC7 -PIN	14 X
( ) ( )	IC 3 -PIN 7 TO IC7 -PIN	16 X & IC14 PIN 35
( ) ( )	IC 3 -PIN 8 TO IC7 -PIN	18 X & IC18 PIN 11
( ) ( )	IC 3 -PIN 9 TO IC8 -PIN	18 X
( ) ( )	IC 3 -PIN 10 TO IC8 -PIN	17 X
( ) ( )	IC 3 -PIN 11 TO IC8 -PIN	16 X
( ) ( )	IC 3 -PIN 12 TO-----	GND
( ) ( )	IC 3 -PIN 13 TO IC8 -PIN	15 X
( ) ( )	IC 3 -PIN 14 TO IC8 -PIN	14 X
( ) ( )	IC 3 -PIN 15 TO IC8 -PIN	13 X
( ) ( )	IC 3 -PIN 16 TO IC8 -PIN	12 X
( ) ( )	IC 3 -PIN 17 TO IC8 -PIN	11 X
( ) ( )	IC 3 -PIN 18 TO IC3 -PIN	20
( ) ( )	IC 3 -PIN 19 TO IC6 -PIN	14 X
( ) ( )	IC 3 -PIN 20 TO IC9 -PIN	1 X
( ) ( )	IC 3 -PIN 21 TO IC12-PIN	3 X
( ) ( )	IC 3 -PIN 22 TO IC6 -PIN	16 X
( ) ( )	IC 3 -PIN 23 TO IC6 -PIN	18 X
( ) ( )	IC 3 -PIN 24 TO-----	+5V

IC 4      Name MC6802      Pins 40

```
( ) ( ) IC 4 -PIN 1 TO ----- GND
( ) ( ) IC 4 -PIN 2 TO IC4 -PIN 3 & IC4 PIN35
( ) ( ) IC 4 -PIN 3 TO IC4 -PIN 8 X
( ) ( ) IC 4 -PIN 4 TO IC18-PIN 7 & 2.7 OHM PULLUP +5V
( ) ( ) IC 4 -PIN 5 TO IC11-PIN 1
( ) ( ) IC 4 -PIN 6 TO IC4 -PIN 8
( ) ( ) IC 4 -PIN 7 TO -----NC
( ) ( ) IC 4 -PIN 8 TO -----X +5V
( ) ( ) IC 4 -PIN 9 TO IC7 -PIN 2
( ) ( ) IC 4 -PIN 10 TO IC7 -PIN 4
( ) ( ) IC 4 -PIN 11 TO IC7 -PIN 6
( ) ( ) IC 4 -PIN 12 TO IC7 -PIN 8
( ) ( ) IC 4 -PIN 13 TO IC7 -PIN 11
( ) ( ) IC 4 -PIN 14 TO IC7 -PIN 13
( ) ( ) IC 4 -PIN 15 TO IC7 -PIN 15
( ) ( ) IC 4 -PIN 16 TO IC7 -PIN 17
( ) ( ) IC 4 -PIN 17 TO IC6 -PIN 2
( ) ( ) IC 4 -PIN 18 TO IC6 -PIN 4
( ) ( ) IC 4 -PIN 19 TO IC6 -PIN 6
( ) ( ) IC 4 -PIN 20 TO IC6 -PIN 8
( ) ( ) IC 4 -PIN 21 -----GND
( ) ( ) IC 4 -PIN 22 TO IC6 -PIN 11
( ) ( ) IC 4 -PIN 23 TO IC6 -PIN 13
( ) ( ) IC 4 -PIN 24 TO IC6 -PIN 15
( ) ( ) IC 4 -PIN 25 TO IC6 -PIN 17
( ) ( ) IC 4 -PIN 26 TO IC8 -PIN 9
( ) ( ) IC 4 -PIN 27 TO IC8 -PIN 8
( ) ( ) IC 4 -PIN 28 TO IC8 -PIN 7
( ) ( ) IC 4 -PIN 29 TO IC8 -PIN 6
( ) ( ) IC 4 -PIN 30 TO IC8 -PIN 5
( ) ( ) IC 4 -PIN 31 TO IC8 -PIN 4
( ) ( ) IC 4 -PIN 32 TO IC8 -PIN 3
( ) ( ) IC 4 -PIN 33 TO IC8 -PIN 2
( ) ( ) IC 4 -PIN 34 TO IC16-PIN 15
( ) ( ) IC 4 -PIN 35 TO-----X
( ) ( ) IC 4 -PIN 36 TO----- GND
( ) ( ) IC 4 -PIN 37 TO IC16-PIN 13
( ) ( ) IC 4 -PIN 38 TO-----4 MHZ XTAL BYPASS 10PF
                           TO GND
( ) ( ) IC 4 -PIN 39 TO-----4 MHZ XTAL BYPASS 10PF
                           TO GND
( ) ( ) IC 4 -PIN 40 TO IC14-PIN 34 & 2.7K OHM PULL UP
                           TO +5V 22 MFD IN PARALLEL W/SPST SW TO GND
```

IC 5	Name 2716	Pins 24
( ) ( )	IC 5 -PIN 1 TO IC	-PIN X
( ) ( )	IC 5 -PIN 2 TO IC	-PIN X
( ) ( )	IC 5 -PIN 3 TO IC	-PIN X
( ) ( )	IC 5 -PIN 4 TO IC	-PIN X
( ) ( )	IC 5 -PIN 5 TO IC	-PIN X
( ) ( )	IC 5 -PIN 6 TO IC	-PIN X
( ) ( )	IC 5 -PIN 7 TO IC	-PIN X
( ) ( )	IC 5 -PIN 8 TO IC	-PIN X
( ) ( )	IC 5 -PIN 9 TO IC18-PIN 22	X
( ) ( )	IC 5 -PIN 10 TO IC18-PIN 21	X
( ) ( )	IC 5 -PIN 11 TO IC18-PIN 20	X
( ) ( )	IC 5 -PIN 12 TO-----	GND
( ) ( )	IC 5 -PIN 13 TO IC18-PIN 19	X
( ) ( )	IC 5 -PIN 14 TO IC18-PIN 18	X
( ) ( )	IC 5 -PIN 15 TO IC18-PIN 17	X
( ) ( )	IC 5 -PIN 16 TO IC18-PIN 16	X
( ) ( )	IC 5 -PIN 17 TO IC18-PIN 15	X
( ) ( )	IC 5 -PIN 18 TO-----	GND
( ) ( )	IC 5 -PIN 19 TO IC	-PIN X
( ) ( )	IC 5 -PIN 20 TO IC13-PIN 17	
( ) ( )	IC 5 -PIN 21 TO IC5	-PIN 24
( ) ( )	IC 5 -PIN 22 TO IC	-PIN X
( ) ( )	IC 5 -PIN 23 TO IC	-PIN X
( ) ( )	IC 5 -PIN 24 TO-----	+5V

IC 6	Name 74241	Pins 20
( ) ( )	IC 6 -PIN 1 TO	----- GND
( ) ( )	IC 6 -PIN 2 TO IC	-PIN X
( ) ( )	IC 6 -PIN 3 TO IC9	-PIN 18 & IC12 PIN 1
( ) ( )	IC 6 -PIN 4 TO IC	-PIN X
( ) ( )	IC 6 -PIN 5 TO IC9	-PIN 20
( ) ( )	IC 6 -PIN 6 TO IC	-PIN X
( ) ( )	IC 6 -PIN 7 TO IC9	-PIN 21
( ) ( )	IC 6 -PIN 8 TO IC	-PIN X
( ) ( )	IC 6 -PIN 9 TO IC9	-PIN 22
( ) ( )	IC 6 -PIN 10 TO	-----GND
( ) ( )	IC 6 -PIN 11 TO IC	-PIN X
( ) ( )	IC 6 -PIN 12 TO IC9	-PIN 23
( ) ( )	IC 6 -PIN 13 TO IC	-PIN X
( ) ( )	IC 6 -PIN 14 TO IC	-PIN X
( ) ( )	IC 6 -PIN 15 TO IC	-PIN X
( ) ( )	IC 6 -PIN 16 TO IC	-PIN X
( ) ( )	IC 6 -PIN 17 TO IC	-PIN X
( ) ( )	IC 6 -PIN 18 TO IC	-PIN X
( ) ( )	IC 6 -PIN 19 TO IC6	-PIN 20
( ) ( )	IC 6 -PIN 20 TO	----- +5V X

IC 7	Name 74241	Pins 20
( ) ( )	IC 7 -PIN 1 TO	----- GND
( ) ( )	IC 7 -PIN 2 TO IC	-PIN X
( ) ( )	IC 7 -PIN 3 TO IC	-PIN X
( ) ( )	IC 7 -PIN 4 TO IC	-PIN X
( ) ( )	IC 7 -PIN 5 TO IC	-PIN X
( ) ( )	IC 7 -PIN 6 TO IC	-PIN X
( ) ( )	IC 7 -PIN 7 TO IC	-PIN X
( ) ( )	IC 7 -PIN 8 TO IC	-PIN X
( ) ( )	IC 7 -PIN 9 TO IC	-PIN X
( ) ( )	IC 7 -PIN 10 TO	----- X
( ) ( )	IC 7 -PIN 11 TO IC	-PIN X
( ) ( )	IC 7 -PIN 12 TO IC	-PIN X
( ) ( )	IC 7 -PIN 13 TO IC	-PIN X
( ) ( )	IC 7 -PIN 14 TO IC	-PIN X
( ) ( )	IC 7 -PIN 15 TO IC	-PIN X
( ) ( )	IC 7 -PIN 16 TO IC	-PIN X
( ) ( )	IC 7 -PIN 17 TO IC	-PIN X
( ) ( )	IC 7 -PIN 18 TO IC	-PIN X
( ) ( )	IC 7 -PIN 19 TO	----- +5V
( ) ( )	IC 7 -PIN 20 TO	----- +5V

IC 8	Name 74245	Pins 20
( ) ( )	IC 8 -PIN 1 TO IC12-PIN 4	
( ) ( )	IC 8 -PIN 2 TO IC -PIN X	
( ) ( )	IC 8 -PIN 3 TO IC -PIN X	
( ) ( )	IC 8 -PIN 4 TO IC -PIN X	
( ) ( )	IC 8 -PIN 5 TO IC -PIN X	
( ) ( )	IC 8 -PIN 6 TO IC -PIN X	
( ) ( )	IC 8 -PIN 7 TO IC -PIN X	
( ) ( )	IC 8 -PIN 8 TO IC -PIN X	
( ) ( )	IC 8 -PIN 9 TO IC -PIN X	
( ) ( )	IC 8 -PIN 10 TO----- GND	
( ) ( )	IC 8 -PIN 11 TO IC -PIN X	
( ) ( )	IC 8 -PIN 12 TO IC -PIN X	
( ) ( )	IC 8 -PIN 13 TO IC -PIN X	
( ) ( )	IC 8 -PIN 14 TO IC -PIN X	
( ) ( )	IC 8 -PIN 15 TO IC -PIN X	
( ) ( )	IC 8 -PIN 16 TO IC -PIN X	
( ) ( )	IC 8 -PIN 17 TO IC -PIN X	
( ) ( )	IC 8 -PIN 18 TO IC -PIN X	
( ) ( )	IC 8 -PIN 19 TO IC11-PIN 6	
( ) ( )	IC 8 -PIN 20 TO----- +5V X	

IC 9	Name 74154	Pins 24
( ) ( )	IC 9 -PIN 1 TO IC	-PIN X
( ) ( )	IC 9 -PIN 2 TO IC	-PIN X
( ) ( )	IC 9 -PIN 3 TO IC	-PIN X
( ) ( )	IC 9 -PIN 4 TO	----- NC
( ) ( )	IC 9 -PIN 5 TO	----- NC
( ) ( )	IC 9 -PIN 6 TO	----- NC
( ) ( )	IC 9 -PIN 7 TO	----- NC
( ) ( )	IC 9 -PIN 8 TO	----- NC
( ) ( )	IC 9 -PIN 9 TO	----- NC
( ) ( )	IC 9 -PIN 10 TO	----- NC
( ) ( )	IC 9 -PIN 11 TO	----- NC
( ) ( )	IC 9 -PIN 12 TO	----- GND
( ) ( )	IC 9 -PIN 13 TO	----- NC
( ) ( )	IC 9 -PIN 14 TO	----- NC
( ) ( )	IC 9 -PIN 15 TO	----- NC
( ) ( )	IC 9 -PIN 16 TO	----- NC
( ) ( )	IC 9 -PIN 17 TO	----- NC
( ) ( )	IC 9 -PIN 18 TO IC	-PIN X
( ) ( )	IC 9 -PIN 19 TO IC11-PIN 3 & IC13	PIN 19
( ) ( )	IC 9 -PIN 20 TO IC13-PIN 20	X
( ) ( )	IC 9 -PIN 21 TO IC13-PIN 21	X
( ) ( )	IC 9 -PIN 22 TO IC13-PIN 22	X
( ) ( )	IC 9 -PIN 23 TO IC13-PIN 23	X
( ) ( )	IC 9 -PIN 24 TO	----- +5V



IC 10      Name 1489      Pins 14

( ) ( ) IC 10 -PIN 1 TO----- INPUT WIRE  
( ) ( ) IC 10 -PIN 2 TO----- NC  
( ) ( ) IC 10 -PIN 3 TO IC18-PIN 2  
( ) ( ) IC 10 -PIN 4 TO----- NC  
( ) ( ) IC 10 -PIN 5 TO----- NC  
( ) ( ) IC 10 -PIN 6 TO----- NC  
( ) ( ) IC 10 -PIN 7 TO----- GND  
( ) ( ) IC 10 -PIN 8 TO----- NC  
( ) ( ) IC 10 -PIN 9 TO----- NC  
( ) ( ) IC 10 -PIN 10 TO----- NC  
( ) ( ) IC 10 -PIN 11 TO----- NC  
( ) ( ) IC 10 -PIN 12 TO----- NC  
( ) ( ) IC 10 -PIN 13 TO----- NC  
( ) ( ) IC 10 -PIN 14 TO----- +5V

IC 11      Name 7400              Pins 14

( ) ( ) IC 11 -PIN 1 TO IC11-PIN 4 X  
( ) ( ) IC 11 -PIN 2 TO IC16-PIN 7 & IC18 PIN 14  
( ) ( ) IC 11 -PIN 3 TO IC -PIN X  
( ) ( ) IC 11 -PIN 4 TO IC -PIN X  
( ) ( ) IC 11 -PIN 5 TO IC11-PIN 14  
( ) ( ) IC 11 -PIN 6 TO IC -PIN X  
( ) ( ) IC 11 -PIN 7 TO----- GND  
( ) ( ) IC 11 -PIN 8 TO----- NC  
( ) ( ) IC 11 -PIN 9 TO----- NC  
( ) ( ) IC 11 -PIN 10 TO----- NC  
( ) ( ) IC 11 -PIN 11 TO----- NC  
( ) ( ) IC 11 -PIN 12 TO----- NC  
( ) ( ) IC 11 -PIN 13 TO----- NC  
( ) ( ) IC 11 -PIN 14 TO 1C -PIN +5V X

IC 12	Name 7404	Pins 14
( ) ( )	IC 12 -PIN 1 TO IC	-PIN X
( ) ( )	IC 12 -PIN 2 TO IC13-	PIN 18
( ) ( )	IC 12 -PIN 3 TO IC16-	PIN 5 X
( ) ( )	IC 12 -PIN 4 TO IC	-PIN X
( ) ( )	IC 12 -PIN 5 TO-----	NC
( ) ( )	IC 12 -PIN 6 TO-----	NC
( ) ( )	IC 12 -PIN 7 TO-----	GND
( ) ( )	IC 12 -PIN 8 TO-----	NC
( ) ( )	IC 12 -PIN 9 TO-----	NC
( ) ( )	IC 12 -PIN 10 TO-----	NC
( ) ( )	IC 12 -PIN 11 TO-----	NC
( ) ( )	IC 12 -PIN 12 TO-----	NC
( ) ( )	IC 12 -PIN 13 TO-----	NC
( ) ( )	IC 12 -PIN 14 TO-----	+5V

IC 13	Name 74154	Pins 24
( ) ( )	IC 13 -PIN 1	TO----- NC
( ) ( )	IC 13 -PIN 2	TO----- NC
( ) ( )	IC 13 -PIN 3	TO----- NC
( ) ( )	IC 13 -PIN 4	TO----- NC
( ) ( )	IC 13 -PIN 5	TO----- NC
( ) ( )	IC 13 -PIN 6	TO----- NC
( ) ( )	IC 13 -PIN 7	TO----- NC
( ) ( )	IC 13 -PIN 8	TO----- NC
( ) ( )	IC 13 -PIN 9	TO----- NC
( ) ( )	IC 13 -PIN 10	TO----- NC
( ) ( )	IC 13 -PIN 11	TO----- NC
( ) ( )	IC 13 -PIN 12	TO----- GND
( ) ( )	IC 13 -PIN 13	TO IC15-PIN 23
( ) ( )	IC 13 -PIN 14	TO IC14-PIN 23
( ) ( )	IC 13 -PIN 15	TO IC18-PIN 9
( ) ( )	IC 13 -PIN 16	TO----- NC
( ) ( )	IC 13 -PIN 17	TO IC -PIN X
( ) ( )	IC 13 -PIN 18	TO IC -PIN X
( ) ( )	IC 13 -PIN 19	TO IC -PIN X
( ) ( )	IC 13 -PIN 20	TO IC -PIN X
( ) ( )	IC 13 -PIN 21	TO IC -PIN X
( ) ( )	IC 13 -PIN 22	TO IC -PIN X
( ) ( )	IC 13 -PIN 23	TO IC -PIN X
( ) ( )	IC 13 -PIN 24	TO----- +5V

IC 14      Name MC6821      Pins 40

```

( ) ( ) IC 14 -PIN 1 TO----- GND
( ) ( ) IC 14 -PIN 2 TO IC22-PIN 1
( ) ( ) IC 14 -PIN 3 TO IC22-PIN 16
( ) ( ) IC 14 -PIN 4 TO IC22-PIN 2
( ) ( ) IC 14 -PIN 5 TO IC22-PIN 15
( ) ( ) IC 14 -PIN 6 TO IC22-PIN 3
( ) ( ) IC 14 -PIN 7 TO IC22-PIN 14
( ) ( ) IC 14 -PIN 8 TO IC22-PIN 4
( ) ( ) IC 14 -PIN 9 TO IC22-PIN 13
( ) ( ) IC 14 -PIN 10 TO----- DIP 2 SWITCH 1
( ) ( ) IC 14 -PIN 11 TO----- DIP 2 SWITCH 2
( ) ( ) IC 14 -PIN 12 TO----- DIP 2 SWITCH 3
( ) ( ) IC 14 -PIN 13 TO----- DIP 2 SWITCH 4
( ) ( ) IC 14 -PIN 14 TO----- DIP 2 SWITCH 5
( ) ( ) IC 14 -PIN 15 TO----- DIP 2 SWITCH 6
( ) ( ) IC 14 -PIN 16 TO----- DIP 2 SWITCH 7
( ) ( ) IC 14 -PIN 17 TO----- DIP 2 SWITCH 8
( ) ( ) IC 14 -PIN 18 TO----- NC
( ) ( ) IC 14 -PIN 19 TO----- NC
( ) ( ) IC 14 -PIN 20 TO IC14-PIN 22
( ) ( ) IC 14 -PIN 21 TO IC15-PIN 21 & IC18 PIN 14
( ) ( ) IC 14 -PIN 22 TO IC14-PIN 24 X
( ) ( ) IC 14 -PIN 23 TO IC -PIN X
( ) ( ) IC 14 -PIN 24 TO IC -PIN X +5V
( ) ( ) IC 14 -PIN 25 TO IC15-PIN 25 & IC18 PIN 14
( ) ( ) IC 14 -PIN 26 TO IC15-PIN 26 & IC18 PIN 15
( ) ( ) IC 14 -PIN 27 TO IC15-PIN 27 & IC18 PIN 16
( ) ( ) IC 14 -PIN 28 TO IC15-PIN 28 & IC18 PIN 17
( ) ( ) IC 14 -PIN 29 TO IC15-PIN 29 & IC18 PIN 18
( ) ( ) IC 14 -PIN 30 TO IC15-PIN 30 & IC18 PIN 19
( ) ( ) IC 14 -PIN 31 TO IC15-PIN 31 & IC18 PIN 20
( ) ( ) IC 14 -PIN 32 TO IC15-PIN 32 & IC18 PIN 21
( ) ( ) IC 14 -PIN 33 TO IC15-PIN 33 & IC18 PIN 22
( ) ( ) IC 14 -PIN 34 TO IC15-PIN 34 X
( ) ( ) IC 14 -PIN 35 TO IC15-PIN 35 X
( ) ( ) IC 14 -PIN 36 TO IC15-PIN 36 & IC18 PIN 11
( ) ( ) IC 14 -PIN 37 TO----- NC
( ) ( ) IC 14 -PIN 38 TO----- NC
( ) ( ) IC 14 -PIN 39 TO----- NC
( ) ( ) IC 14 -PIN 40 TO----- NC

```

IC 15      Name MC6821      Pins 40

```

( ) ( ) IC 15 -PIN 1 TO----- GND
( ) ( ) IC 15 -PIN 2 TO IC16-PIN 2
( ) ( ) IC 15 -PIN 3 TO IC16-PIN 4
( ) ( ) IC 15 -PIN 4 TO IC16-PIN 6
( ) ( ) IC 15 -PIN 5 TO IC16-PIN 8
( ) ( ) IC 15 -PIN 6 TO IC16-PIN 11
( ) ( ) IC 15 -PIN 7 TO IC16-PIN 17
( ) ( ) IC 15 -PIN 8 TO----- NC
( ) ( ) IC 15 -PIN 9 TO----- NC
( ) ( ) IC 15 -PIN 10 TO IC17-PIN 2
( ) ( ) IC 15 -PIN 11 TO IC17-PIN 4
( ) ( ) IC 15 -PIN 12 TO IC17-PIN 6
( ) ( ) IC 15 -PIN 13 TO IC17-PIN 8
( ) ( ) IC 15 -PIN 14 TO IC17-PIN 11
( ) ( ) IC 15 -PIN 15 TO IC17-PIN 13
( ) ( ) IC 15 -PIN 16 TO IC17-PIN 15
( ) ( ) IC 15 -PIN 17 TO IC17-PIN 17
( ) ( ) IC 15 -PIN 18 TO----- NC
( ) ( ) IC 15 -PIN 19 TO----- NC
( ) ( ) IC 15 -PIN 20 TO----- +5V
( ) ( ) IC 15 -PIN 21 TO IC -PIN X
( ) ( ) IC 15 -PIN 22 TO IC15-PIN 24
( ) ( ) IC 15 -PIN 23 TO IC -PIN X
( ) ( ) IC 15 -PIN 24 TO IC -PIN X +5V
( ) ( ) IC 15 -PIN 25 TO IC -PIN X
( ) ( ) IC 15 -PIN 26 TO IC -PIN X
( ) ( ) IC 15 -PIN 27 TO IC -PIN X
( ) ( ) IC 15 -PIN 28 TO IC -PIN X
( ) ( ) IC 15 -PIN 29 TO IC -PIN X
( ) ( ) IC 15 -PIN 30 TO IC -PIN X
( ) ( ) IC 15 -PIN 31 TO IC -PIN X
( ) ( ) IC 15 -PIN 32 TO IC -PIN X
( ) ( ) IC 15 -PIN 33 TO IC -PIN X
( ) ( ) IC 15 -PIN 34 TO IC -PIN X
( ) ( ) IC 15 -PIN 35 TO IC -PIN X
( ) ( ) IC 15 -PIN 36 TO IC -PIN X
( ) ( ) IC 15 -PIN 37 TO----- NC
( ) ( ) IC 15 -PIN 38 TO----- NC
( ) ( ) IC 15 -PIN 39 TO----- NC
( ) ( ) IC 15 -PIN 40 TO----- NC

```

IC 16      Name 74241      Pins 20

( ) ( ) IC 16 -PIN 1 TO----- GND  
( ) ( ) IC 16 -PIN 2 TO IC -PIN  
( ) ( ) IC 16 -PIN 3 TO IC21-PIN 10  
( ) ( ) IC 16 -PIN 4 TO IC -PIN X  
( ) ( ) IC 16 -PIN 5 TO IC18-PIN 13    X  
( ) ( ) IC 16 -PIN 6 TO IC -PIN X  
( ) ( ) IC 16 -PIN 7 TO IC -PIN X  
( ) ( ) IC 16 -PIN 8 TO IC -PIN X  
( ) ( ) IC 16 -PIN 9 TO IC21-PIN 11  
( ) ( ) IC 16 -PIN 10 TO----- GND  
( ) ( ) IC 16 -PIN 11 TO IC -PIN X  
( ) ( ) IC 16 -PIN 12 TO IC21-PIN 11  
( ) ( ) IC 16 -PIN 13 TO IC -PIN X  
( ) ( ) IC 16 -PIN 14 TO IC21-PIN 6  
( ) ( ) IC 16 -PIN 15 TO IC -PIN X  
( ) ( ) IC 16 -PIN 16 TO IC21-PIN 12  
( ) ( ) IC 16 -PIN 17 TO IC -PIN X  
( ) ( ) IC 16 -PIN 18 TO IC21-PIN 5  
( ) ( ) IC 16 -PIN 19 TO IC16-PIN 20  
( ) ( ) IC 16 -PIN 20 TO----- +5V

IC 17	Name 74241	Pins 20
( ) ( )	IC 17 -PIN 1	TO----- GND
( ) ( )	IC 17 -PIN 2	TO IC -PIN X
( ) ( )	IC 17 -PIN 3	TO IC21-PIN 13
( ) ( )	IC 17 -PIN 4	TO IC -PIN X
( ) ( )	IC 17 -PIN 5	TO IC21-PIN 4
( ) ( )	IC 17 -PIN 6	TO IC -PIN X
( ) ( )	IC 17 -PIN 7	TO IC21-PIN 14
( ) ( )	IC 17 -PIN 8	TO IC -PIN X
( ) ( )	IC 17 -PIN 9	TO IC21-PIN 3
( ) ( )	IC 17 -PIN 10	TO----- GND
( ) ( )	IC 17 -PIN 11	TO IC -PIN X
( ) ( )	IC 17 -PIN 12	TO IC21-PIN 15
( ) ( )	IC 17 -PIN 13	TO IC -PIN X
( ) ( )	IC 17 -PIN 14	TO IC21-PIN 2
( ) ( )	IC 17 -PIN 15	TO IC -PIN X
( ) ( )	IC 17 -PIN 16	TO IC21-PIN 16
( ) ( )	IC 17 -PIN 17	TO IC -PIN X
( ) ( )	IC 17 -PIN 18	TO IC21-PIN 1
( ) ( )	IC 17 -PIN 19	TO IC17-PIN 20
( ) ( )	IC 17 -PIN 20	TO----- +5V X



IC 18	Name MC6850	Pins 24
( ) ( )	IC 18 -PIN 1	TO----- GND
( ) ( )	IC 18 -PIN 2	TO IC20-PIN 3 X
( ) ( )	IC 18 -PIN 3	TO----- DIP 1 IC18 PIN 4 COMMON BAUD RATE IN FROM DIP 1
( ) ( )	IC 18 -PIN 4	TO----- NC X
( ) ( )	IC 18 -PIN 5	TO----- NC
( ) ( )	IC 18 -PIN 6	TO----- NC IC20 PIN 2
( ) ( )	IC 18 -PIN 7	TO IC -PIN X
( ) ( )	IC 18 -PIN 8	TO IC18-PIN 10 & +5V
( ) ( )	IC 18 -PIN 9	TO IC -PIN X
( ) ( )	IC 18 -PIN 10	TO IC18-PIN 12 X
( ) ( )	IC 18 -PIN 11	TO IC -PIN X X
( ) ( )	IC 18 -PIN 12	TO IC -PIN X
( ) ( )	IC 18 -PIN 13	TO IC -PIN X X
( ) ( )	IC 18 -PIN 14	TO IC -PIN X X
( ) ( )	IC 18 -PIN 15	TO IC -PIN X X
( ) ( )	IC 18 -PIN 16	TO IC -PIN X X
( ) ( )	IC 18 -PIN 17	TO IC -PIN X X
( ) ( )	IC 18 -PIN 18	TO IC -PIN X X
( ) ( )	IC 18 -PIN 19	TO IC -PIN X X
( ) ( )	IC 18 -PIN 20	TO IC -PIN X X
( ) ( )	IC 18 -PIN 21	TO IC -PIN X X
( ) ( )	IC 18 -PIN 22	TO IC -PIN X X
( ) ( )	IC 18 -PIN 23	TO----- GND
( ) ( )	IC 18 -PIN 24	TO----- GND

```
( ) ( ) IC 19 -PIN 1 TO-----DIP1 SWITCH 8
( ) ( ) IC 19 -PIN 2 TO -----DIP1 SWITCH 7
( ) ( ) IC 19 -PIN 3 TO -----DIP1 SWITCH 6
( ) ( ) IC 19 -PIN 4 TO -----DIP1 SWITCH 5
( ) ( ) IC 19 -PIN 5 TO -----DIP1 SWITCH 4
( ) ( ) IC 19 -PIN 6 TO -----NC
( ) ( ) IC 19 -PIN 7 TO -----DIP1 SWITCH 3
( ) ( ) IC 19 -PIN 8 TO -----DIP1 SWITCH 2
( ) ( ) IC 19 -PIN 9 TO -----NC
( ) ( ) IC 19 -PIN 10 TO IC19-PIN 22
( ) ( ) IC 19 -PIN 11 TO-----NC
( ) ( ) IC 19 -PIN 12 TO-----GND
( ) ( ) IC 19 -PIN 13 TO-----DIP1 SWITCH 1
( ) ( ) IC 19 -PIN 14 TO-----NC
( ) ( ) IC 19 -PIN 15 TO-----NC
( ) ( ) IC 19 -PIN 16 TO-----NC
( ) ( ) IC 19 -PIN 17 TO-----NC
( ) ( ) IC 19 -PIN 18 TO-----NC
( ) ( ) IC 19 -PIN 19 TO-----NC
( ) ( ) IC 19 -PIN 20 TO>>
                >>1 M OHM PARLLEL 1.8432 M
( ) ( ) IC 19 -PIN 21 TO>>
( ) ( ) IC 19 -PIN 22 TO IC19-PIN 24 X
( ) ( ) IC 19 -PIN 23 TO-----GND
( ) ( ) IC 19 -PIN 24 TO-----+5V
```

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IC 20      Name MC1488      Pins 14

```

( ) ( ) IC 20 -PIN 1 TO -----MINUS 12 V BYPASS 22
                                MFD TO GND
( ) ( ) IC 20 -PIN 2 TO -----X
( ) ( ) IC 20 -PIN 3 TO -----OUTPUT WIRE RS232C
( ) ( ) IC 20 -PIN 4 TO -----NC
( ) ( ) IC 20 -PIN 5 TO -----NC
( ) ( ) IC 20 -PIN 6 TO -----NC
( ) ( ) IC 20 -PIN 7 TO -----GND
( ) ( ) IC 20 -PIN 8 TO -----NC
( ) ( ) IC 20 -PIN 9 TO -----NC
( ) ( ) IC 20 -PIN 10 TO-----NC
( ) ( ) IC 20 -PIN 11 TO-----NC
( ) ( ) IC 20 -PIN 12 TO-----NC
( ) ( ) IC 20 -PIN 13 TO-----NC
( ) ( ) IC 20 -PIN 14 TO----- +12 V BYPASS 22 MFD
                                TO GROUND

```

IC 21	Name I/O	Pins 16
( ) ( )	IC 21 -PIN 1 TO	-----X
( ) ( )	IC 21 -PIN 2 TO	-----X
( ) ( )	IC 21 -PIN 3 TO	-----X
( ) ( )	IC 21 -PIN 4 TO	-----X
( ) ( )	IC 21 -PIN 5 TO	-----X
( ) ( )	IC 21 -PIN 6 TO	-----X
( ) ( )	IC 21 -PIN 7 TO	-----NC
( ) ( )	IC 21 -PIN 8 TO	-----NC
( ) ( )	IC 21 -PIN 9 TO	-----NC
( ) ( )	IC 21 -PIN 10 TO	-----X
( ) ( )	IC 21 -PIN 11 TO	-----X X
( ) ( )	IC 21 -PIN 12 TO	-----X
( ) ( )	IC 21 -PIN 13 TO	-----X
( ) ( )	IC 21 -PIN 14 TO	-----X
( ) ( )	IC 21 -PIN 15 TO	-----X
( ) ( )	IC 21 -PIN 16 TO	-----X

IC 22	Name I/O	Pins 16
( ) ( )	IC 22 -PIN 1 TO	-----X
( ) ( )	IC 22 -PIN 2 TO	-----X
( ) ( )	IC 22 -PIN 3 TO	-----X
( ) ( )	IC 22 -PIN 4 TO	-----X
( ) ( )	IC 22 -PIN 5 TO	-----NC
( ) ( )	IC 22 -PIN 6 TO	-----NC
( ) ( )	IC 22 -PIN 7 TO	-----NC
( ) ( )	IC 22 -PIN 8 TO	-----NC
( ) ( )	IC 22 -PIN 9 TO	-----NC
( ) ( )	IC 22 -PIN 10 TO	-----NC
( ) ( )	IC 22 -PIN 11 TO	-----NC
( ) ( )	IC 22 -PIN 12 TO	-----NC
( ) ( )	IC 22 -PIN 13 TO	-----X
( ) ( )	IC 22 -PIN 14 TO	-----X
( ) ( )	IC 22 -PIN 15 TO	-----X
( ) ( )	IC 22 -PIN 16 TO	-----X

This source program runs with the Zenith C-86 compiler on any Zenith (100, 150, or 240) or fully PC compatible machine. It creates a disk file containing a blank wire wrap list. The program prompts for the IC number, number of pins which that IC has, and the name of the IC. The program accepts output file name on the command line or prompts for one if one is not given on the command line. The program runs in a continuous loop until the escape sequence of "999" is given at the IC number prompt. The program double spaces all ICs with 24 pins or less. It places an ASCII form feed character at the end of each IC in the file. It does not append to the output file. If multiple invocations of the program are required they must be performed with separate output file names and appended externally.

```
#include <stdio.h> /* NAME: WWLIST.C */
main(argc,argv) /* Program makes a blank wire wrap list*/
int argc; /* Accepts file name on command line */
char *argv[2]; /* WWLIST filename */
/* prompts for IC number, number of pins & IC name*/

{
    int icnum, pinum, loop;
    char icname[10];
    FILE *fp, *fopen();

    if ( argc == 1 ) {
        printf("Enter Output File ==> ");
        scanf("%s", argv[1]);
    }

    fp = fopen(*++argv, "w");

    putc('>', fp);

    do {
        printf("\n\n\nEnter IC Number (999 to quit) ==> ");
        scanf("%d", &icnum);

        if (icnum != 999) {
            printf("\nEnter IC Name ==> ");

```

```

scanf("%s", icname);

printf("\nEnter number of pins ==> ");
scanf("%d", &pinum);

fprintf(fp, ".ej;\tIC\tName\tPins\n", icnum, icname, pinum);
printf("\n\tIC\tName\tPins\n", icnum, icname, pinum);
printf("\n\t... printing to file [%s]\n", *argv);

for(loop=1; loop<=pinum; loop++) {
if (pinum <= 24) fprintf (fp, "\n");
    fprintf(fp, "( ) ( ) IC %d -PIN %d TO IC -PIN\n", icnum, loop);
}

    fprintf(fp, "\f");
}

}

while (icnum != 999);

fclose(fp);
return(0);
}

```

---

UPDATEWW.C operates on a file originally created by the WWLIST program to fill in the "where to" data. The program expects two arguments on the command line: the first is the name of the input file to be filled in; the second is the name of the output file to be created.

"UPDATEWW inputfile outputfile"

The program does not prompt for these names from within the program, however this could easily be added by using the routine in WWLIST.C on the previous page. The program may be called repeatedly in case the job can not be completed at one sitting. It should be noted that at subsequent invocations of the program, the latest outputfile name is used as inputfile

and another name must be used for outputfile.

```
#include <stdio.h> /* UPDATEWW.C updates the pin file made
                    by WWLIST */

main(argc, argv) /* FILEIN FILEOUT names on command line!!!
                  */

int argc;
char *argv[];
{
extern int fgetc();
extern int fputc();
extern int fputs();
int ch,i,j,ch1,ch2,flag;

FILE *fpr, *fpw, *fopen();

fpw = fopen(argv[2], "w"); /* write over existing file */

fpr = fopen(argv[1], "r"); /*(+++argv , "r") is same thing*/
                          /* argv is pointer to 0th el */
                          /* *argv is the 0th element */
                          /* argv[0] is the 0th element */

printf("\n%s\n", "ENTER IC NUMBER SPACE PIN NUMBER SPACE
              COMMENTS CR");

printf("%s\n", "FOR EXAMPLE>>>12 1 comments here CR<<< WOULD
              BE FOR");

printf("%s\n", "IC-12 PIN-1 comments here");

printf("%s\n", "FOR JUST IC AND PIN ENTER IC NUMBER PIN
              NUMBER CR");

printf("%s\n", "FOR JUST A COMMENT FIELD ENTER SPACE COMMENTS
              CR");

printf("%s\n", "TO STOP INPUTING TYPE > AT THE END OF A
              COMMENT FIELD");
```



```

ch2 = '\0';
ch1 = '\0';
flag = 0;

while ((ch = fgetc(fpr)) != '>') putc(ch, fpw);

while ((ch = fgetc(fpr)) != EOF)
{
ch2 = ch1;
ch1 = ch;

if(ch2 == '\0') continue;

if(ch2 != '\12' && flag == 1) continue;

putc(ch2, stdout); putc(ch2, fpw);

if(ch2 == '\12') { flag = 0; continue;}

if(ch2 == 'O') {
    ch = fgetc(stdin) ;

    if(ch != ' ') {
        putc(' ', stdout); putc(' ', fpw);
        putc('I', stdout); putc('I', fpw);
        putc('C', stdout); putc('C', fpw);
        putc('-', stdout); putc('-', fpw);
        putc(ch, stdout); putc(ch, fpw);
        ch = fgetc(stdin);
        putc(ch, stdout); putc(ch, fpw);

        if(ch != ' ') { ch = fgetc(stdin); /*this must
                                                be a space*/

                                putc(ch, stdout); putc(ch, fpw);
                                }
        putc('P', stdout); putc('P', fpw);
        putc('I', stdout); putc('I', fpw);
        putc('N', stdout); putc('N', fpw);
        putc('-', stdout); putc('-', fpw);

        flag = 1;
    }
}

```

```

    }
/* if ch after 0 was a space comment only to be input */
if(flag == 0) { for(i=1;i<14;i++) { putc('-', stdout);
    putc('-', fpw);} }

    while ((ch = fgetc(stdin)) != '\12')

        {
            putc(ch, stdout);

            putc(ch, fpw);

            if(ch == '>') goto done; }

        flag = 1;

    }

}

putc(ch1, stdout); putc(ch1, fpw);

goto dn2;

done: while((ch = fgetc(fpr)) != '\12') continue ;
    putc(ch, fpw);
    while((ch = fgetc(fpr)) != EOF) putc(ch,fpw);

dn2:  fclose(fpr);
    fclose(fpw);
}

```

#### SS50 MICROPROCESSOR SYSTEM (6800):

A brief description of the mother board will be given before considering the actual central processing unit (CPU) board. Figure 4 is a schematic diagram of the mother board electronics. The mother board provides all the sockets into which the CPU card, memory cards, and all input/output (I/O) cards are placed. The mother board provides 50 single sided contacts at each of the main sockets. Fifty printed circuit lines connect all of the main sockets in parallel on the back side of the mother board. Sixteen of the lines are used as unidirectional address lines (the signal is put out by the microprocessor and received by all other cards). These sixteen lines allow the microprocessor to specify which (any one of 65,536 possible) memory location it wishes to communicate with. Eight of these lines are used as bidirectional data lines. These eight lines allow a number (between 0 and 255) to be transferred either from the microprocessor to a memory location or from a memory location to the microprocessor. A master reset line is provided with a 1K pull up resistor to +5V. When the master reset line is pulled low it performs a hardware reset of the 6800 microprocessor. A reset line is provided with a 470 ohm resistor to +5V. This reset line is driven low any time a master reset occurs. This line provides a clean TTL pulse to reset devices which must be provided with a reset pulse. VMA (valid memory address) is provided to tell the memory devices when the signals on the memory lines are valid requests (the microprocessor places random junk on the address lines during certain internal processes). A line is provided for each of the two clock signals used by the microprocessor for internal timing (phase-1 and phase-2). When the phase-2 signal is high and the VMA signal is high, then and only then is the memory cell selected by the address lines enabled for read or write. A read/write line is provided which allows the microprocessor to tell each memory device which is selected whether it is to memorize the signal on the data lines (write), or place the signal stored by it on the data lines (read). Lines are provided for both nonmaskable interrupt (NMI) and interrupt request (IRQ).



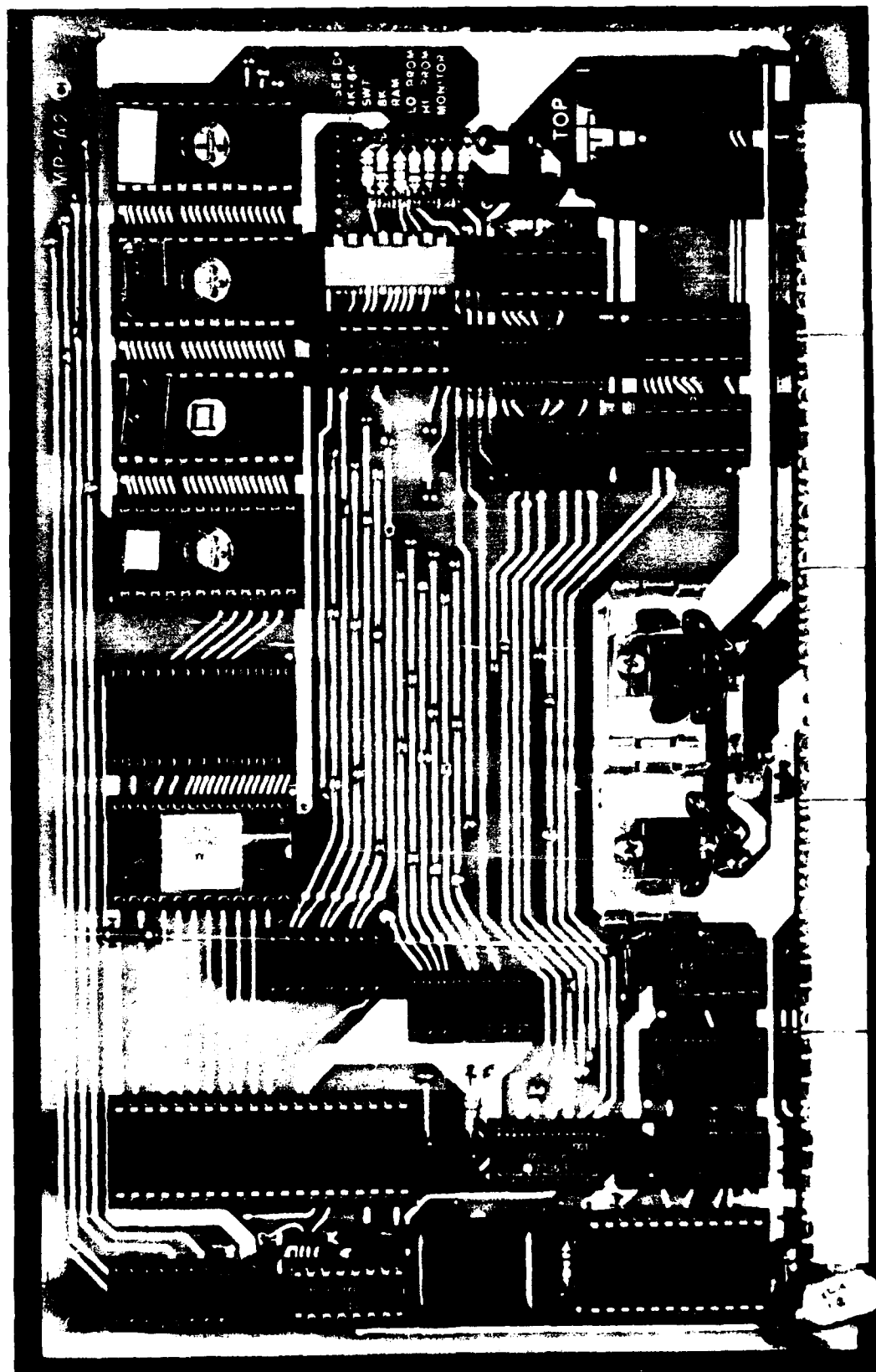
Both of these lines are pulled up to +5V with 6.8K resistors. External devices pull these lines down to interrupt the microprocessor. A halt line is tied to +5V through 470 ohms. If an external device wishes to put its signals on the address lines, it may pull this line low and wait for the bus available line to go high (microprocessor signifying that it has stopped and relinquished the address lines for external use). The remaining five lines which are used on the SS50 bus are five different baud rate clocks. A 16 X clock is provided for the following baud rates: 110, 150, 300, 600, and 1200. In this implementation the 110 baud line has been changed to 9600 baud. In addition to providing interconnect lines between SS50 sockets, the mother board also provides address decoding for eight SS30 I/O slots on the back of the mother board. The decoding circuitry uses address lines A2, A3, A4, A5, A12, A13, A14, and A15 from the CPU card and provides an active low select line at the front of each SS30 I/O socket. The first I/O slot (number zero) is selected for \$8000, \$8001, \$8002, and \$8003. The second slot (number one) is decoded for the next four addresses, etc. , for all eight I/O slots. CPU A0 and A1 are buffered and supplied to all SS30 slots as RS0 and RS1. Thus, four memory locations are available for use at each of the I/O slots (not always used) with a minimum of decode hardware required on the I/O boards. Two 8835s are used to buffer the 8 data lines between the SS50 and SS30 sockets. It should be noted that the I/O slots are not uniquely decoded (address lines A6 through A11 are not used in decoding). This causes each I/O port address to echo through a full 4K of memory (i. e. \$8100 is the 3 -same as \$8000). In addition to the +8V bus, +12 volts and -12 volts are also distributed to both the SS50 and SS30 sockets. It is important to remember that VMA, phase-2, and all of the data lines (D0- D7) are inverted on the SS50 backplane. Inverting drivers correct the sense of these lines before they are used by memory boards, etc. The CPU board (schematic diagram, Figure 5) contains the microprocessor (Motorola 6800), 128 bytes of scratch pad random access memory (6810), 8K bytes of monitor read only memory (2716), and a crystal

controlled baud rate generator (14411). Buffering of data lines to and from the CPU card is done by a pair of four-bit bidirectional inverting line drivers (8835). The direction is controlled by a pair of 7455s, which take into account VMA, R/W, and whether or not the memory address selected is external to the CPU card. Buffering of the sixteen address lines is accomplished with three 74367 line drivers. These buffers are on all the time except when the microprocessor is halted. A halt signal causes the outputs of the 74367s to open (go to a high impedance state) so that an external device may use the address lines. A Motorola 14411 is used to generate baud rate clock signals. These are buffered by sections of a 7404 before going out to the SS50 and SS30 buses. Two 74139 decoder chips, in conjunction with four mechanical switches, are used to select: on-board or external RAM and 2K, 4K, or 8K of on-board monitor ROM. Figures 6 and 7 show the actual top and bottom view of the CPU card. In Figure 6 the four 2716s in the upper right hand corner of the board house the 8K of monitor programs. The option select switches are shown just below these ROMs. The wire shown on the back of the CPU card (Figure 7) is used to supply a 9600 baud sixteen times clock signal, after the 110 baud clock printed circuit line has been cut.

#### SERIAL INTERFACE BOARD:

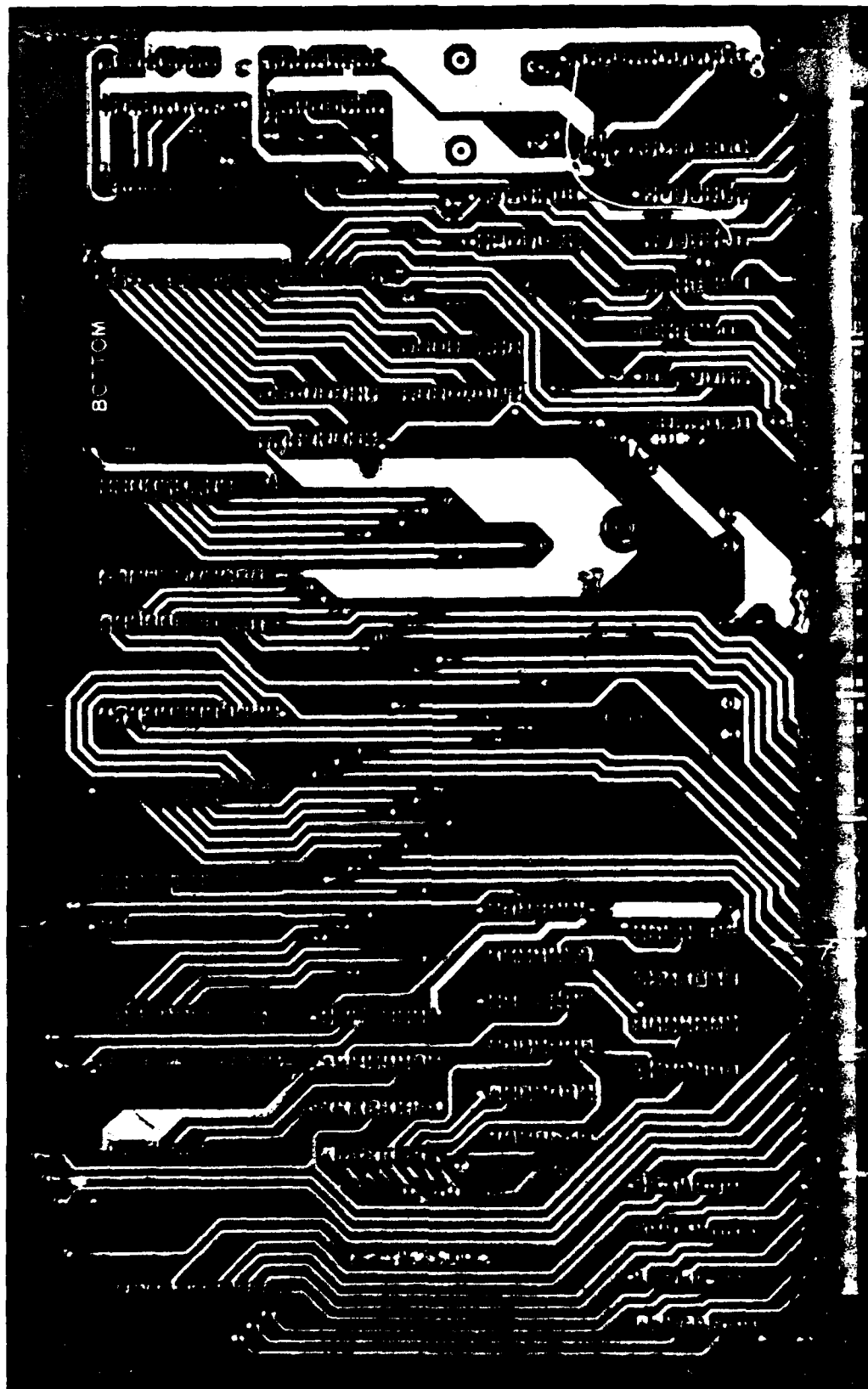
Figure 8 is the schematic diagram for a serial interface card which is installed on port one of the mother board. This card is not used under operating conditions of the automatic test system. However, this card is very important when trouble shooting problems or creating a new system. This board allows one to run the monitor program (memory examine and change, etc. ) and the disk operating system directly from any RS232-C terminal. As can be seen on Figures 9 and 10, only the components associated with RS232-C operation have been installed on this interface card. In particular all three of the 4N33 optical couplers have been left out, and the input to pin 4 of IC-3 was tied low (simulating no input from the 20 mA current loop input). Also a switch was installed on the top edge of the serial





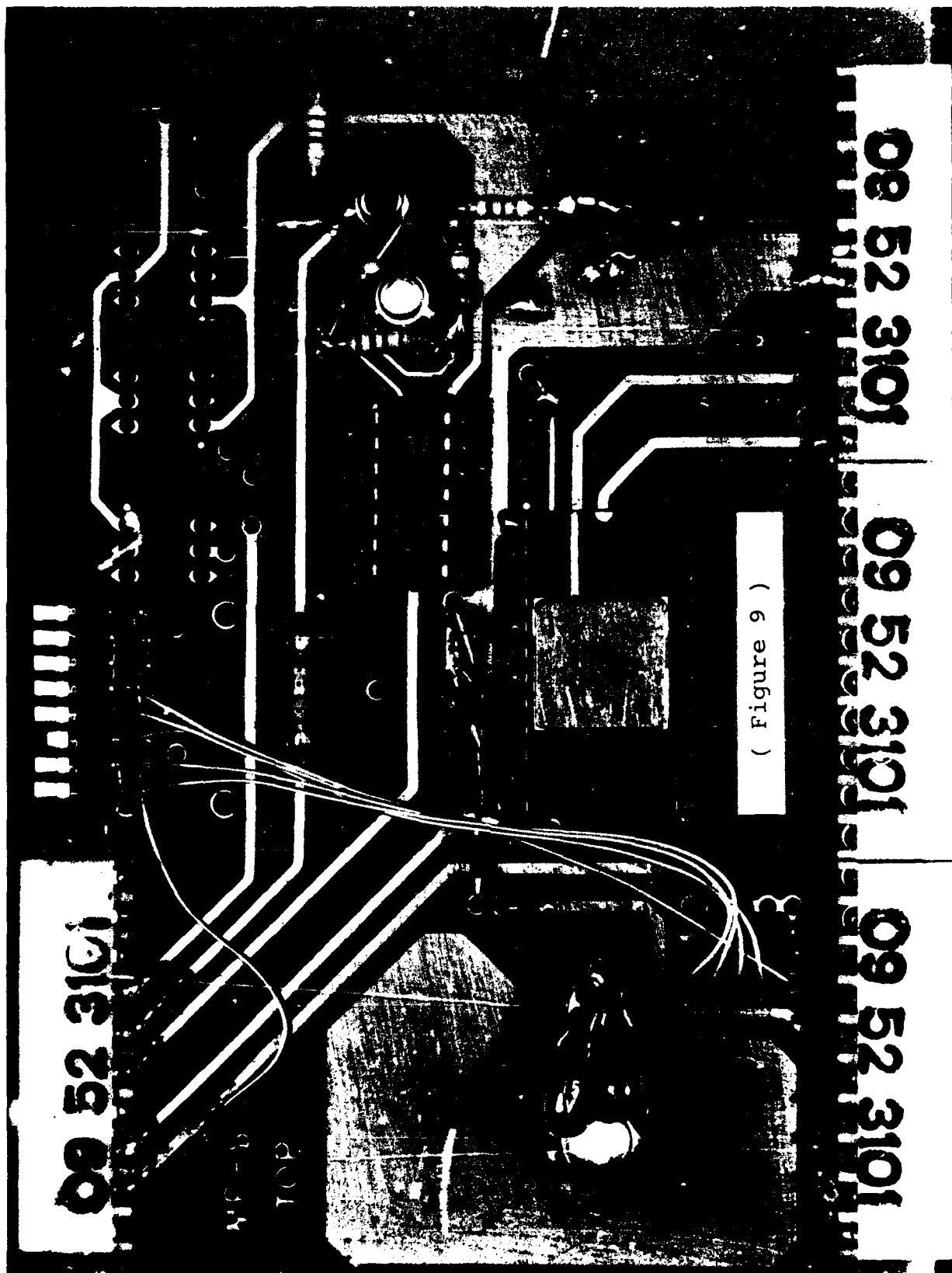
( Figure 6 )

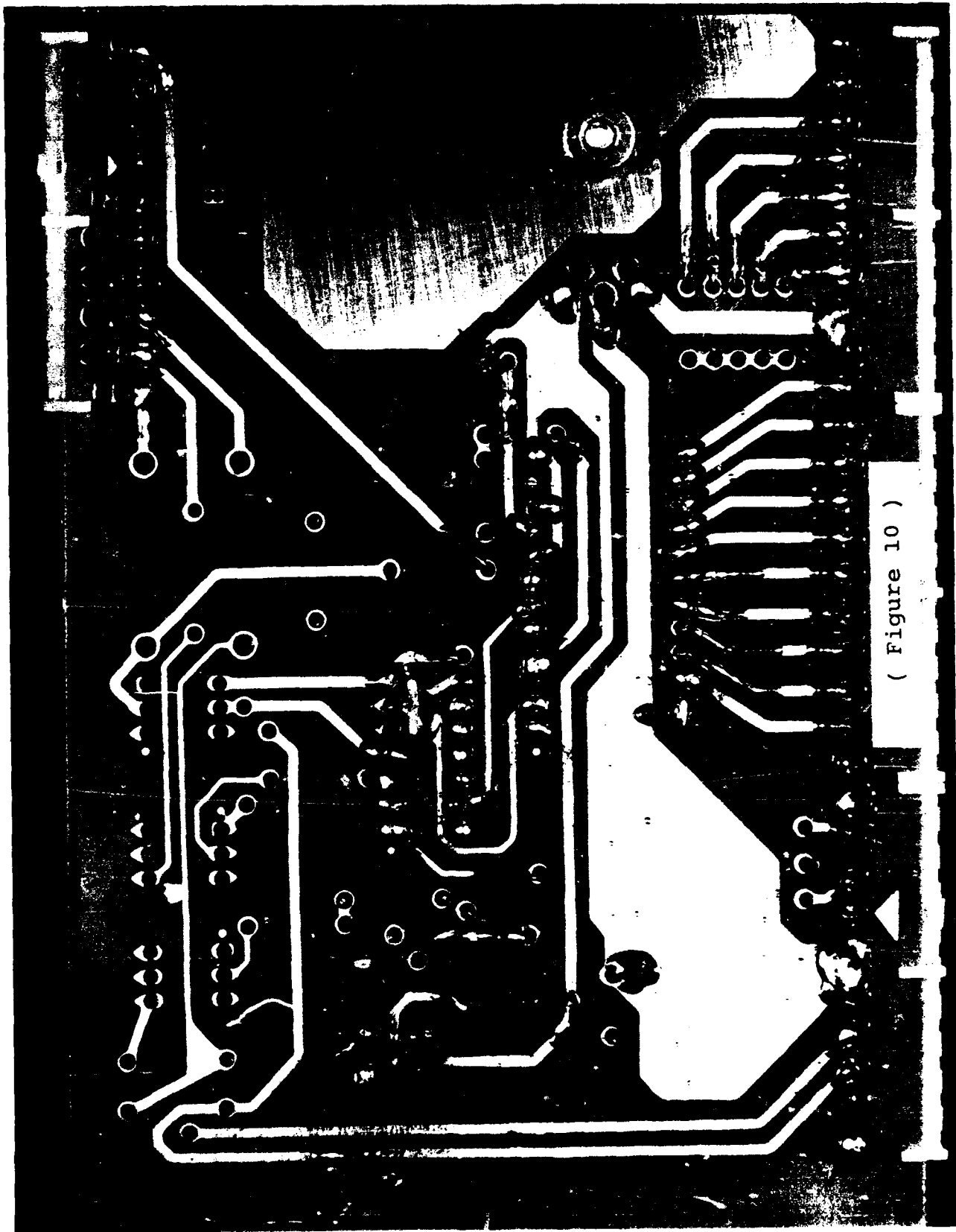




( Figure 7 )







( Figure 10 )

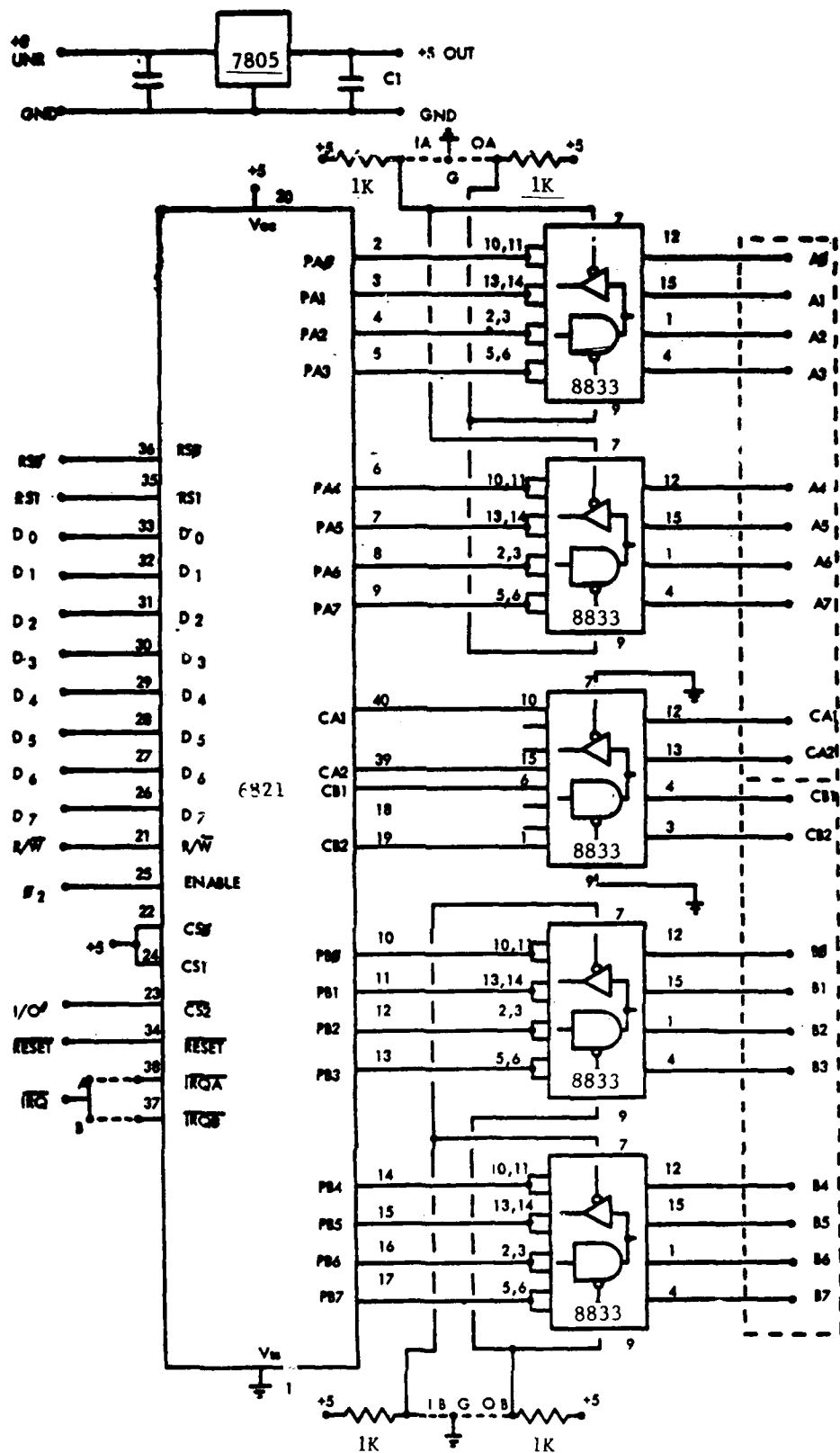
board. This allows the baud rate (16 X clock) to be selected while the board is installed and the system operating. This is significant when a system problem is at hand, and one does not wish to lose all the memory information while connecting some arbitrary serial terminal to do trouble shooting.

#### STANDARD PARALLEL INTERFACE BOARD:

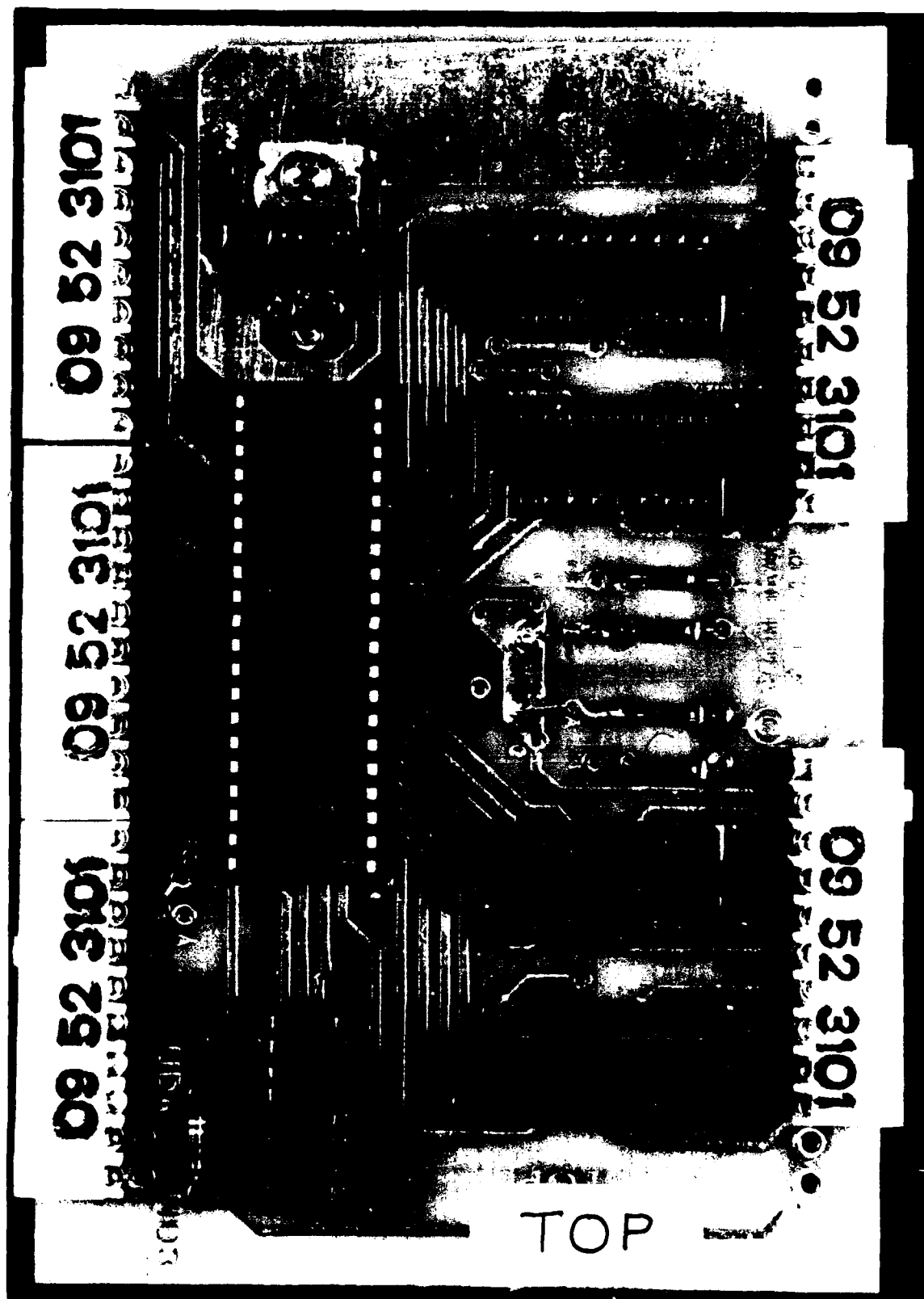
Figure 11 is the schematic diagram for the standard interface board. Figures 12 and 13 show the front and back of this board. Two of these are used in the system, however, only one is described because they are identical. These boards mount on any of the SS30 I/O slots on the back of the mother board. Plus 8 volts (unregulated) from the bus is converted to +5 volts (regulated) by a 7805. It is important that the filter capacitors on the input and output of the 7805 be as close to the regulator as possible (closer than 2 inches). The standard interface board uses a Motorola 6821 to interface to the computer, and five 8833 line drivers to interface between the 6821 and the external devices. The 8833 drivers have standard TTL driver outputs. In addition to setting the 6821 for either input or output (direction of signal flow) with the proper computer commands, a jumper on the circuit board must tell the 8833 line drivers to go in the same direction.

#### OPEN COLLECTOR PARALLEL INTERFACE BOARD:

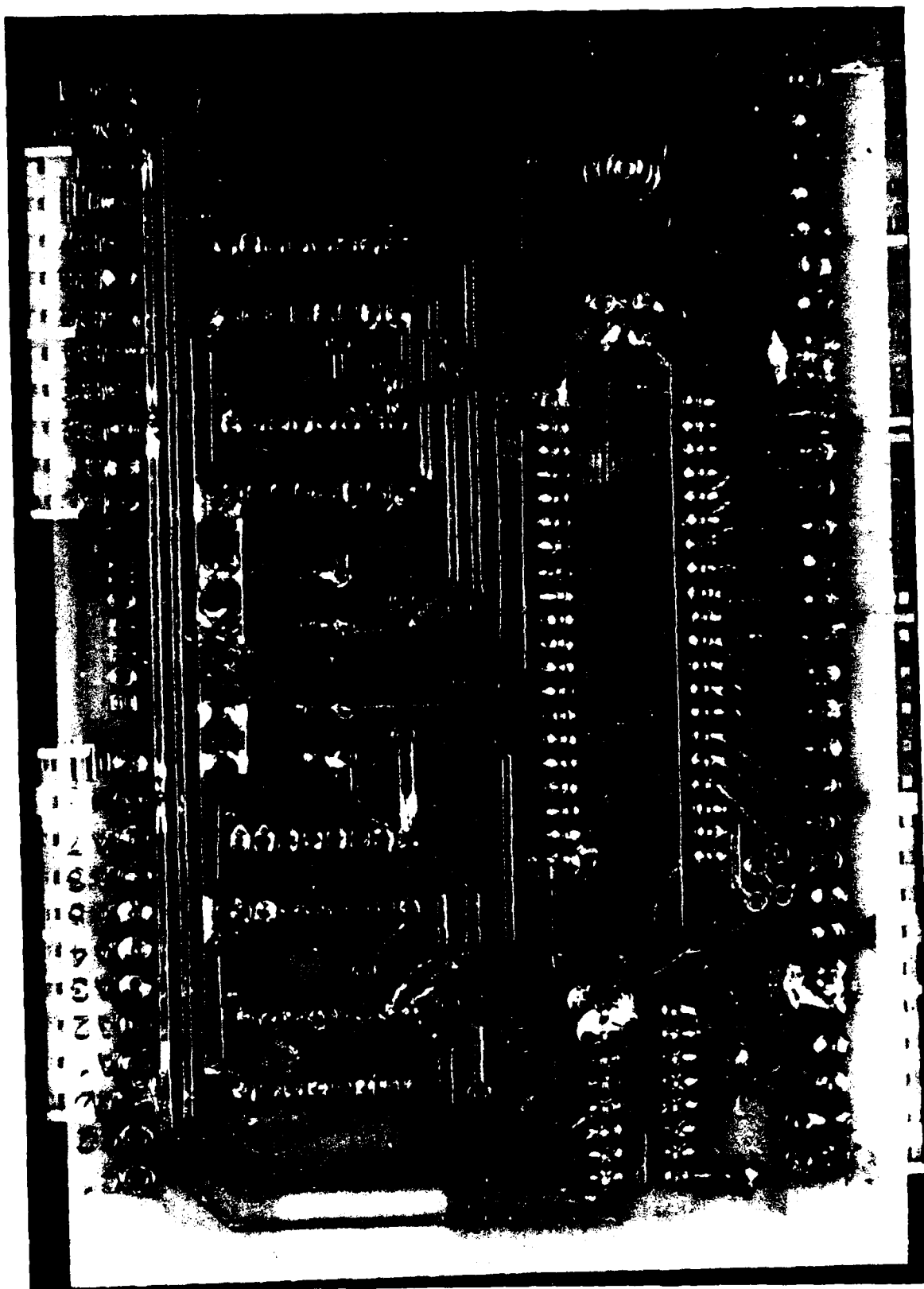
Figure 14 is the schematic diagram for this board and Figures 15 and 16 show the front and back of the printed circuit card. This board mounts on any of the SS30 I/O slots on the back of the mother board. Plus 8 volts (unregulated) from the bus is converted to +5 volts (regulated) by a 7805. It is important that the filter capacitors on the input and output of the 7805 be as close to the regulator as possible (closer than 2 inches). The open collector interface board uses a Motorola 6821 to interface to the computer, and three 7407 open collector noninverting buffers to interface between the 6821 and the external devices. The 7407 drivers have high voltage open collector outputs. This



( Figure 11 )

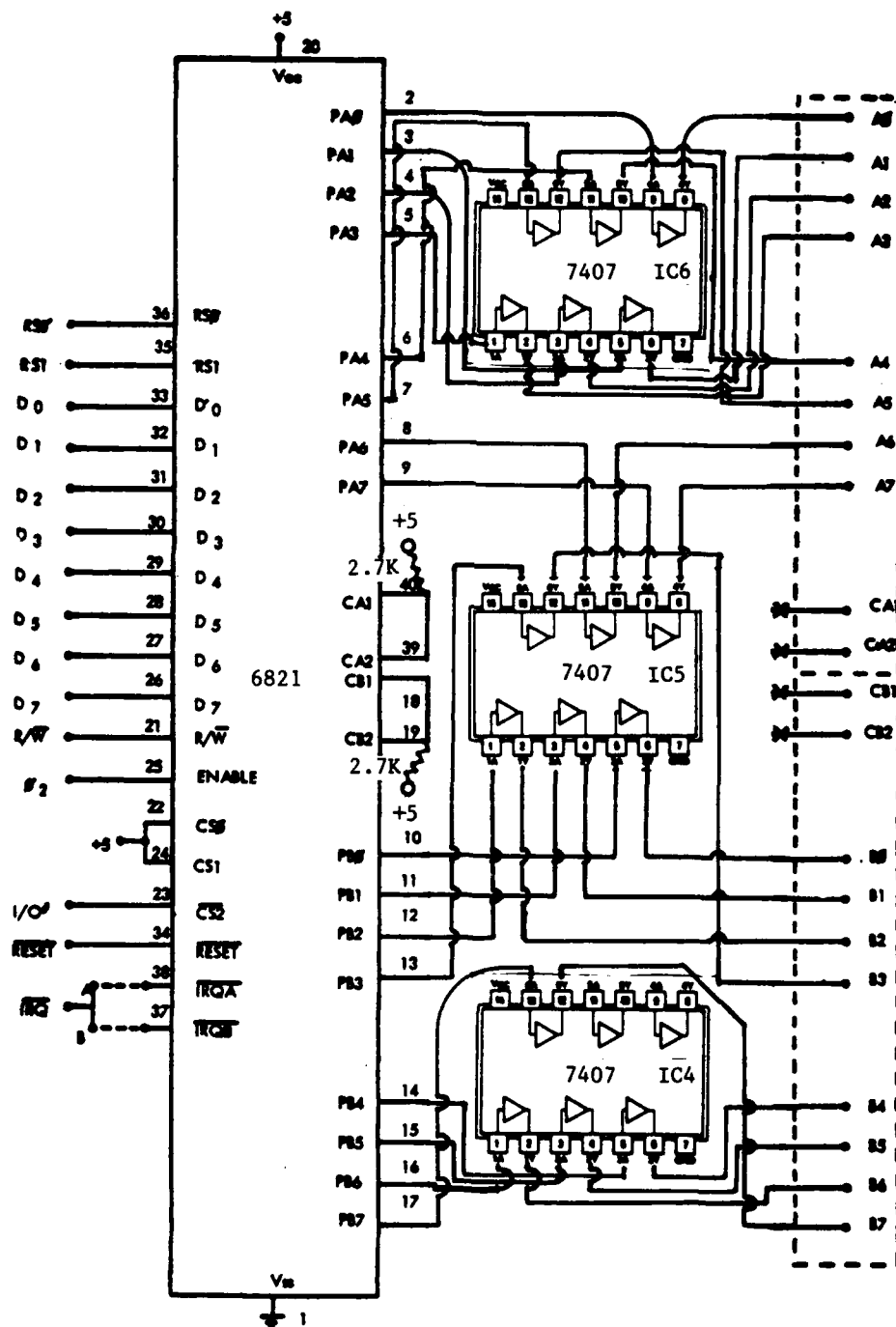
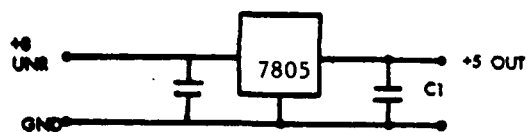


( Figure 12 )

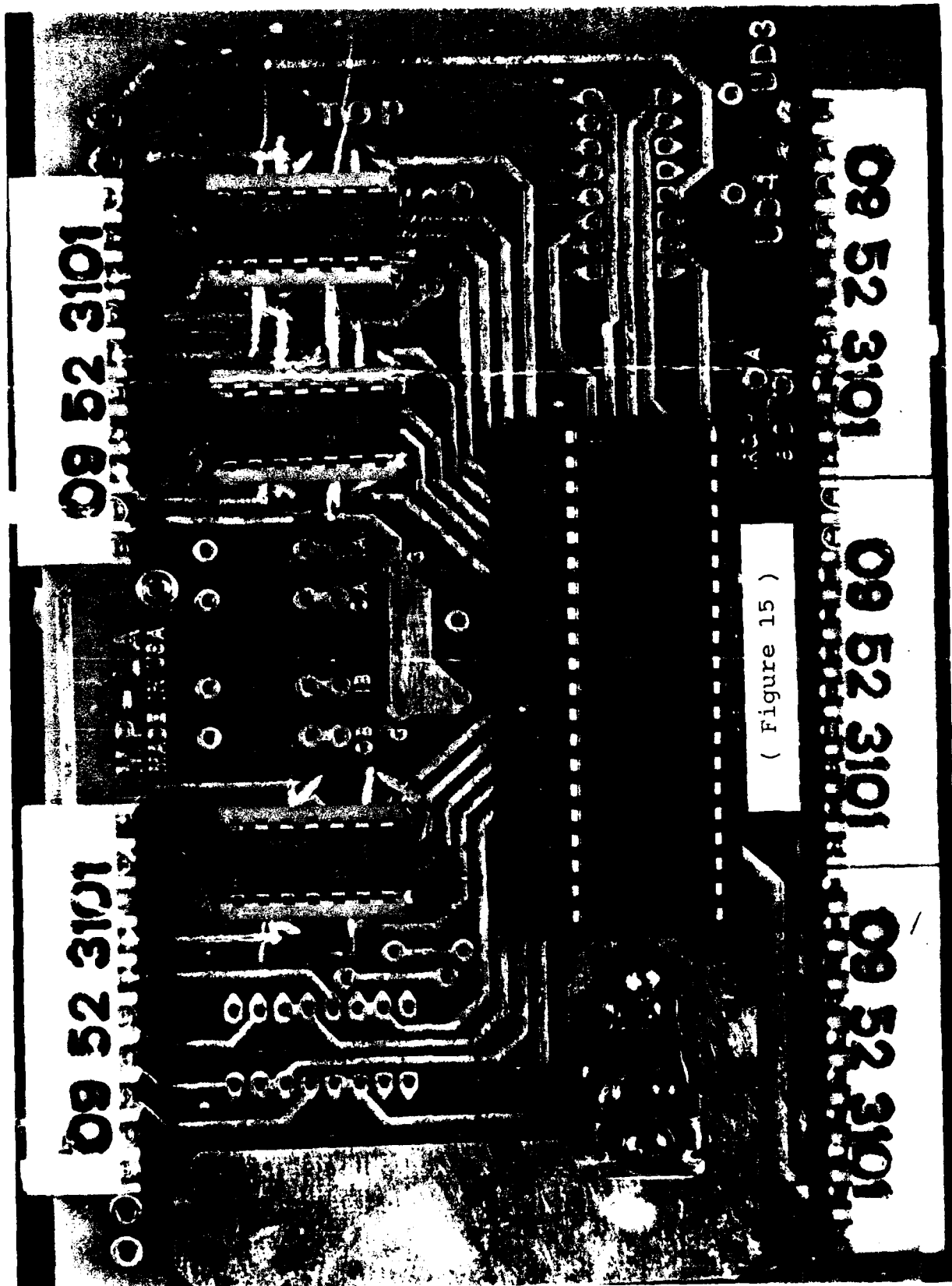


( Figure 13 )

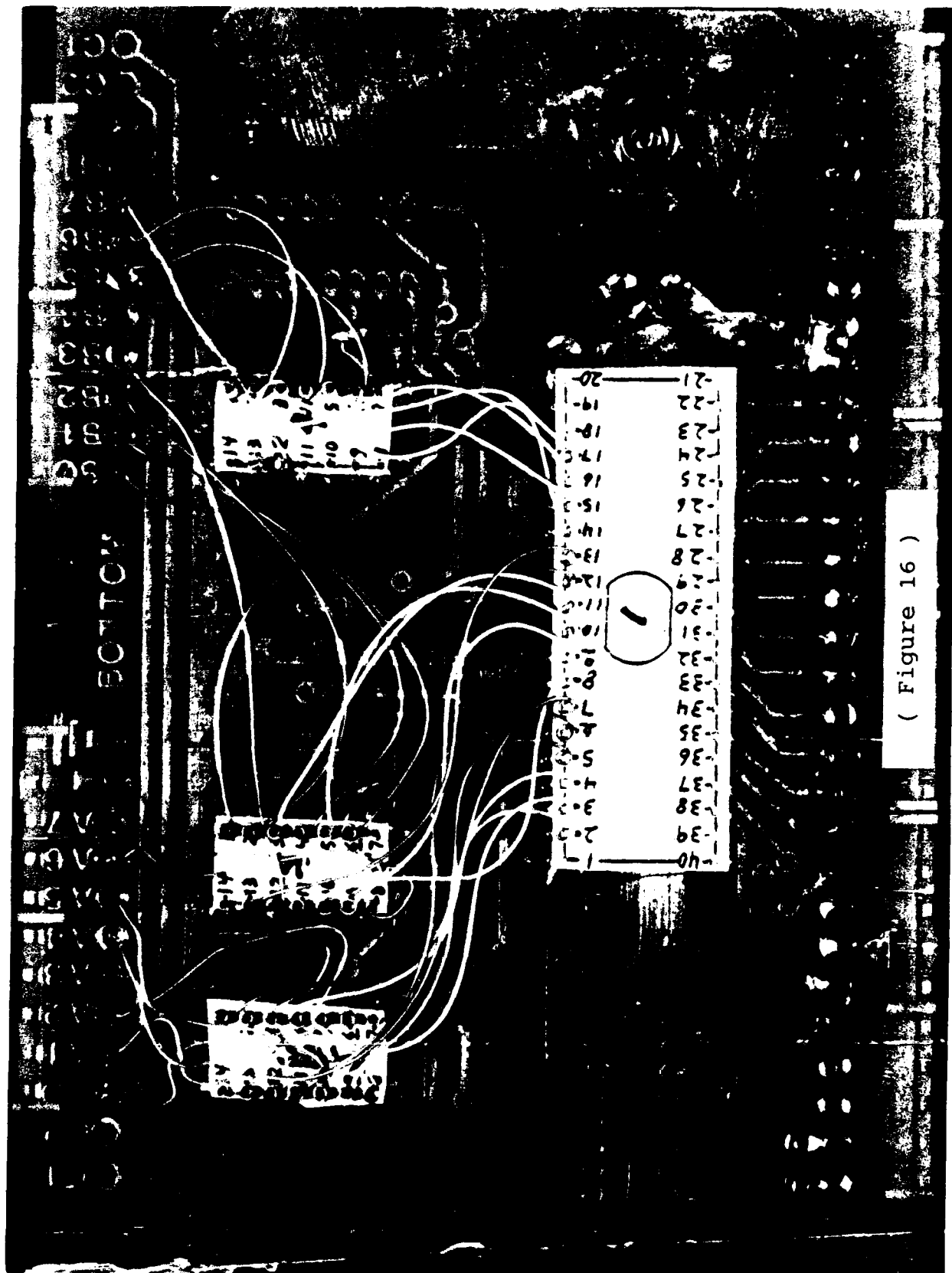




( Figure 14 )



( Figure 15 )



board is designed to provide outputs from the CPU only. However, the CPU must set the data direction register in the 6821 for data output.

#### SS50 SYSTEM MEMORY ALLOCATION:

Sixteen binary address lines allow the CPU to directly select any one memory byte out of 64K (a K is actually 1,024 bytes, the number of different codes possible with ten binary address lines).

The lowest 256 bytes (\$0000-\$00FF) of memory are reserved for temporary variable storage. This is highly desirable because only eight address lines are involved in selection. This feature allows the CPU to read or write to these locations much faster than possible at higher locations.

The memory from (\$0100-\$0FFF) is where the system measurement programs reside. These programs control the operation of all measurement hardware.

The memory from (\$1000-\$1FFF) is used for binary coded decimal data storage. This intermediate data storage is later read to magnetic disk when a test run is complete.

The memory from (\$2000-\$5000) is not used during normal system operation. This space is used to run DEBUG diagnostic programs when required.

The memory from (\$6000-\$67FF) is used by a system executive command file program. This EXEC program runs all the disk resident programs which are required to perform the life test.

The memory from (\$6800-\$6FFF) is used by a subroutine driver which stores and keeps track of memory pointers for all data stored by the system.

The disk operating system resides at (\$7000-\$7FFF). This system contains all the drivers which are required to read and write files to and from the magnetic disk

drive.

Input and output boards are addressed at (\$8000-\$8FFF). Only the first 32 bytes are actually used, however, these are not completely decoded and echo through the entire block.

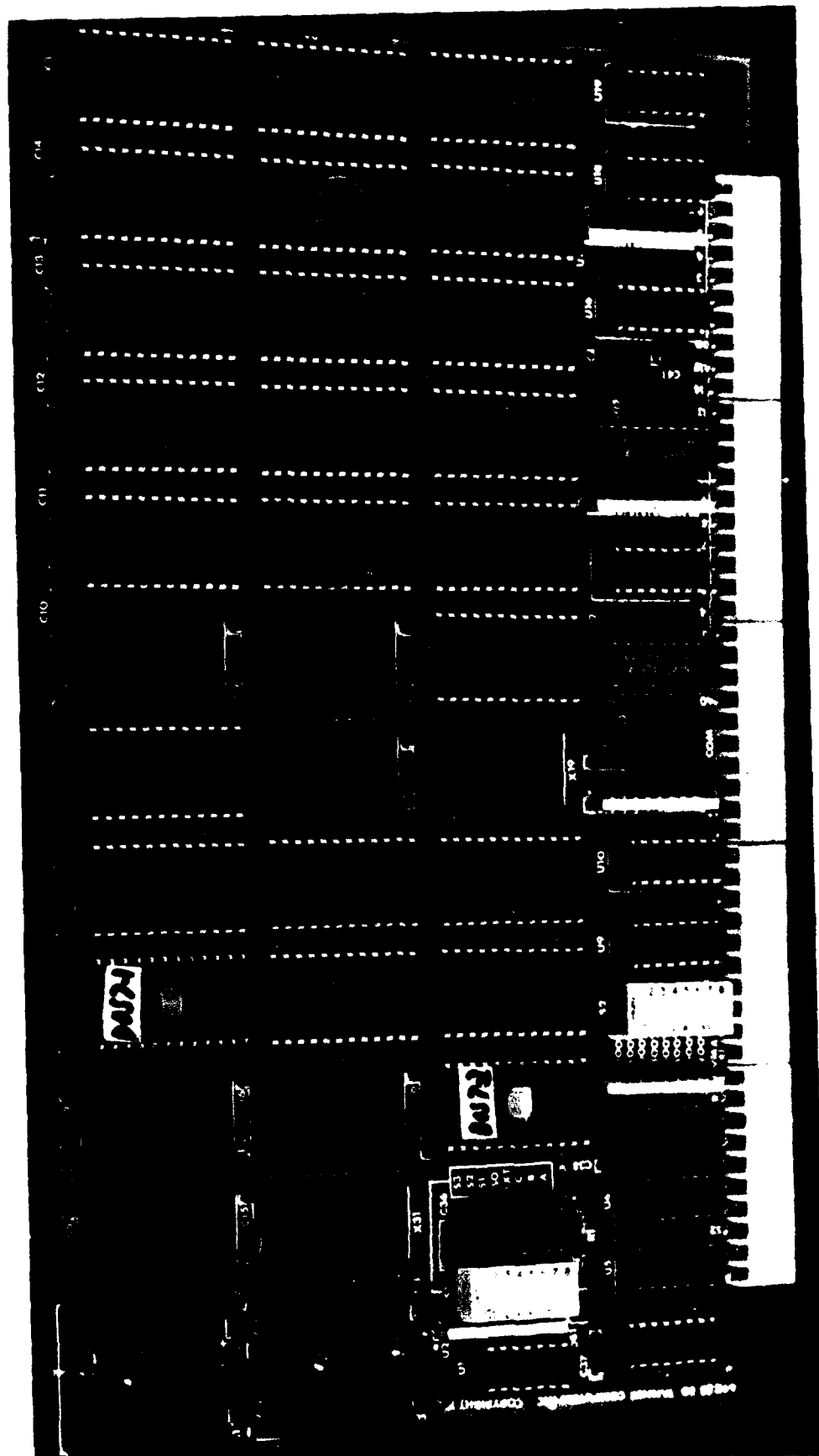
The CPU uses the memory at (\$A000-\$A0FF) as program push down stack. This keeps track of return locations for subroutines ,etc.

The highest 8K of memory (\$E000-\$FFFF) is used by CPU monitor read only memory (ROM). Subroutine calls to and from a diagnostic terminal are made through this ROM.

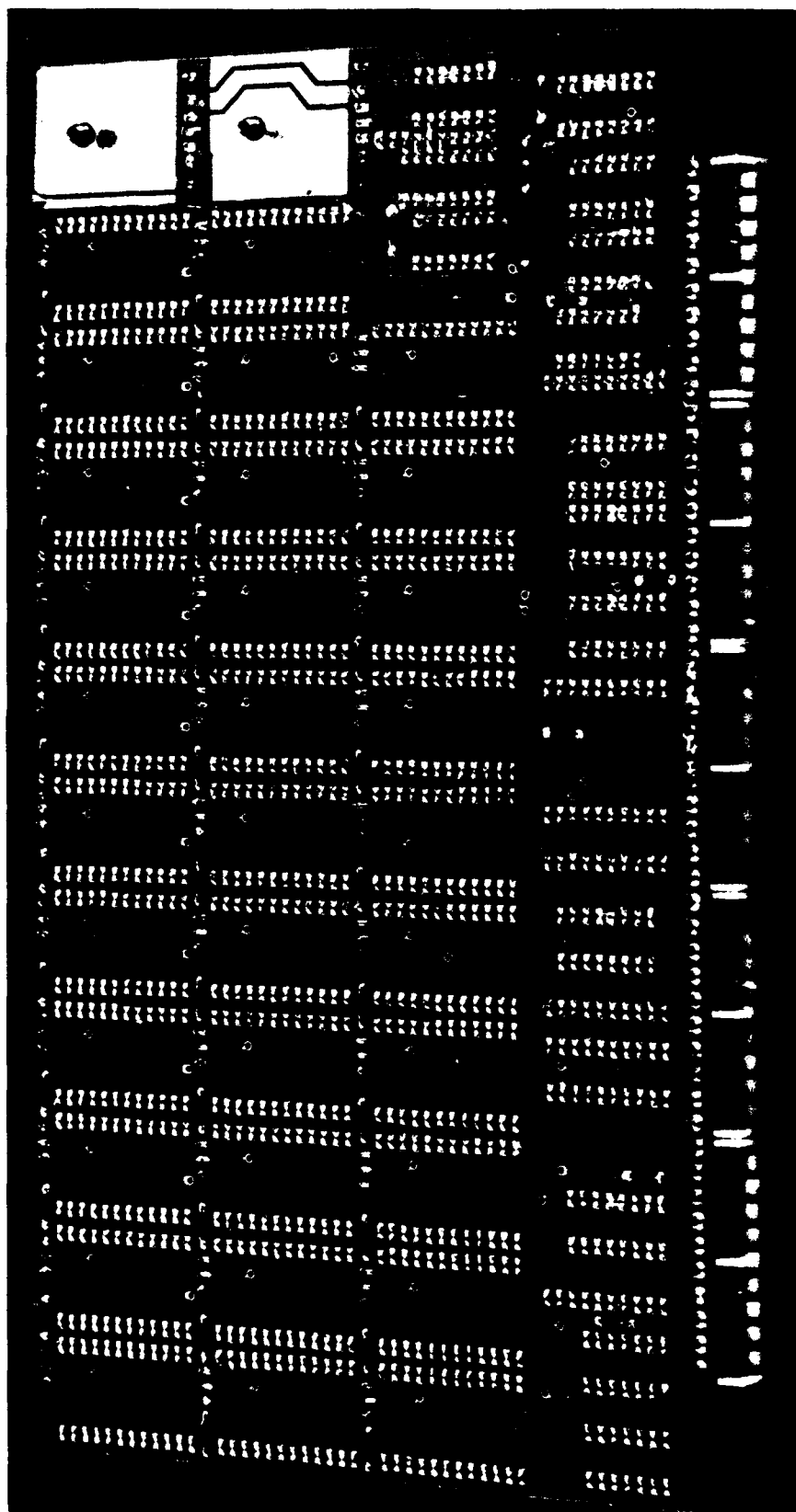
Figures 17 and 18 show the top and bottom views of a representative memory board. The board shown is populated with 2K by 8 CMOS memory chips. It provides contiguous memory from \$0000 to \$7FFF with the sixteen chips on the right-hand side of the memory board. The other memory chips on this card are not used in the automatic life test system and will not be described here. The jumper shown in Figure 18 is part of a modification of the original memory board. This modification prevents the line drivers on the memory board from being selected at the \$8000 block (where I/O is decoded in the measurement system).

#### POWER SUPPLY:

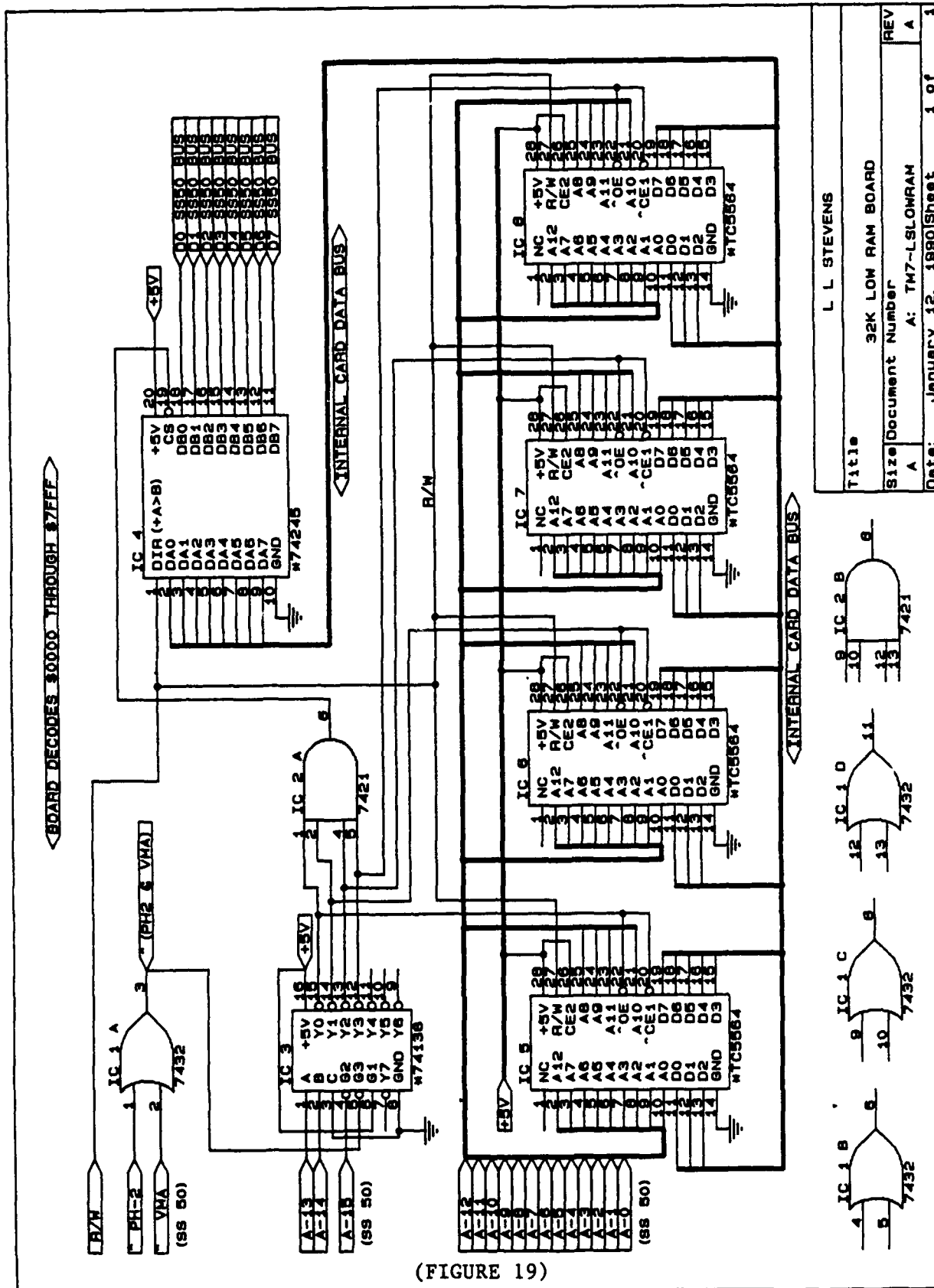
The system power supply provides the required regulated DC voltages. It should be noted that some of these voltages are further regulated by the circuit card where the power is used. This is done primarily to provide better noise isolation. The supply includes the necessary heat sinking and air cooling fan to enable continuous operation of the measurement system.



( Figure 17 )



( Figure 18 )



(FIGURE 19)



# REAL-TIME CLOCK/CALENDAR SOFTWARE:

This assembly language program reads and sets the real-time clock/calendar in the SS50 microprocessor system. This program is derived from a program which was used initially to test the clock hardware. The hardware contains a ten-year battery, so that it maintains the correct time and date when power is removed from the SS50 system, or the clock board is removed from the system.

Figure 20 on page 107 shows a simple clock/calendar schematic without any system implications. Figure 21 on page 108 shows the clock/calendar chip (ICM7170) with associated buffer and decode hardware needed to run it on the SS50 system. This software was written for the SS50 implementation of Figure 21 on page 108. Figures 23 and 24 show top and bottom views of the actual wire wrap board.

```
8      PAGE 001  CLOCK
9
10
11
12
13          NAM      CLOCK
14          OPT      O,S,NOP,NOG
15      0100          ORG      $0100
16
17          *
18          * THIS PROGRAM READS & SETS A REAL-TIME
19          * CLOCK LOCATED AT $C100 THRU $C111
20
21          * BECAUSE OF INVERTING BUFFERS
22          * ON THE CPU BOARD THE DATA COMES
23          * BACK INVERTED FROM THE CLOCK
24
25          *$C100 IS THE HUNDREDTHS COUNTER
26          *****
27          ***** $C100 MUST BE READ FIRST TO *****
28          *****
29          .***UPDATE THE LATCH FOR REST OF COUNTERS
30          **THESE REMAIN UNTIL $C100 IS READ AGAIN.
31
32          *$C1XX: 00=1/100 SEC AND LATCH
```

27	*	01=HOURS (AND 12/24 MODE)
28	*	02=MINUTES
29	*	03=SECONDS
30	*	04=MONTH
31	*	05=DAY OF MONTH
32	*	06=YEAR
33	*	07=DAY OF WEEK
34	*	08=RAM 1/100SEC FOR ALARM
35	*	09=RAM HOURS FOR ALARM
36	*	0A=RAM MINUTES FOR ALARM
37	*	0B=RAM SECONDS FOR ALARM
38	*	0C=RAM MONTH FOR ALARM
39	*	0D=RAM DAY OF MONTH FOR ALARM
40	*	0E=RAM YEAR FOR ALARM
41	*	0F=RAM DAY OF WEEK FOR ALARM
42	*	10=IRQ STATUS AND MASK REGISTER
43	*	11=COMMAND REGISTER
44	*	

THE FOLLOWING EQU LINES DEFINE MEMORY LOCATIONS  
IN TERMS OF NAMES, SO THE NAMES MAY CONVENIENTLY BE USED  
THROUGHOUT THE REST OF THE PROGRAM

45	E1AC	IN	EQU	\$E1AC	THIS SUB INPUTS ONE CHARACTER FROM THE COMPUTER TERMINAL
46	E07E	PDAT1	EQU	\$E07E	THIS SUB PRINTS STRING TO THE COMPUTER SCREEN
47	C111	CMDR	EQU	\$C111	CLOCK COMMAND REGISTER
48	C100	HSEC	EQU	\$C100	HUNDREDTHS SECONDS
49	C103	SEC	EQU	\$C103	SECONDS
50	C102	MIN	EQU	\$C102	MINUTES
51	C101	HR	EQU	\$C101	HOURS
52	C105	DAYM	EQU	\$C105	DAY OF MONTH
53	C104	MMONT	EQU	\$C104	MONTH

```

54      C106      YR      EQU      $C106      YEAR
55      C107      DAYW     EQU      $C107      DAY OF WEEK
56      *
57      *
58      *$F3 IN COMMAND REG IS NORMAL RUN
59      *      24 HOUR MODE IRQ DISABLED

60      *$FB COMMAND STOPS CLOCK SO TIME
61      *      CAN BE SET BY WRITING (COMP)
62      *      OF DESIRED TIME IN C100 THRU C107

63      *      START THE CLOCK BY WRITING $F3 IN THE
        COMMAND REG.
64      *
65      ***THE ABOVE COMANDS ARE ALREADY INVERTED
66      *
67      *
68      *
69      *****THIS PROGRAM WILL READ THE CLOCK*****
        *****AND PRINT THE TIME TO THE TERMINAL*****
        *****WHEN ANY KEY IS PRESSED*****

72      *EXCEPT Q WHICH QUILTS THE PROGRAM TO DOS
73      *      OR S WHICH SETS THE TIME OF CLOCK
74      *

75      0100 CE 0202 START LDX      #OPENS
76      0103 BD E07E      JSR      PDAT1 (PRINT STRING)
77      *
78      0106 A6 00          LDA A    0,X (THIS NOT REQUIRED)
79      0108 CE 023C      LDX      #STRING (POINT TO STRING)
80      010B BD E07E      JSR      PDAT1 (PRINT STRING)
81      010E CE C100      LDX      #$C100 (CLOCK POINTER)
82      0111 A6 00          LDA A    0,X (1/100 SEC & LATCH)
83      0113 43            COM A    (BUFFERS INVERTED THE DATA)
84      0114 B7 0380      STA A    OUT+1
85      0117 A6 03          LDA A    3,X      SECONDS
86      0119 43            COM A
87      011A B7 0382      STA A    OUT+3
88      011D A6 02          LDA A    2,X      MINUTES
89      011F 43            COM A

```

```

90      0120 B7 0384      STA A   OUT+5
91      0123 A6 01       LDA A   1,X      HOURS
92      0125 43          COM A
93      0126 B7 0386      STA A   OUT+7
94      0129 A6 05       LDA A   5,X      DAY OF MONTH
95      012B 43          COM A
96      012C B7 0388      STA A   OUT+9
97      012F A6 04       LDA A   4,X      MONTH
98      0131 43          COM A
99      0132 B7 038A      STA A   OUT+11
100     0135 A6 06       LDA A   6,X      YEAR
101     0137 43          COM A
102     0138 B7 038C      STA A   OUT+13
103
104
105          *PRINT CLOCK NOW FROM DATA
          STORED IN MEMORY ABOVE

106     013B C6 07       LDA B   #7  NUMBER OF DATA ITEMS
107     013D F7 0391      STA B   BTMP

108     0140 CE 037F      LDX     #OUT
109     0143 FF 038F      STX     XTMP
110     0145 FE 038F LP1  LDX     XTMP
111     0149 C6 03       LDA B   #3
112     014B BD 7133      JSR     $7133    OUT-DEC
113     014E 86 20       LDA A   #$20
114     0150 BD E1D1      JSR     $E1D1    OUT-CHARACTER
115     0153 FE 038F      LDX     XTMP
116     0156 08          INX
117     0157 08          INX
118     0158 FF 038F      STX     XTMP
119     015B 7A 0391      DEC     BTMP
120     015E 26 E6       BNE     LP1

121
122          *GET CHARACTER FROM TERMINAL
123          *IF Q THEN EXIT TO DOS
          *IF S THEN SET TIME
          *IF ANYTHING ELSE READ TIME AGAIN

124     0160 BD E1AC      JSR     $E1AC GET CHARACTER

```

```

125    0163 81 51          CMP A  #'Q
126    0165 27 07          BEQ    DN1
127    0167 81 53          CMP A  #'S
128    0169 27 06          BEQ    SET
129    016B 7E 0100        JMP     START
130    016E 7E 7103 DN1    JMP     $7103 SOFT ENTRY TO DOS
131                                     *

```

```

132                                     ***THIS SECTION SETS THE CLOCK TO A GIVEN
133    TIME AND STARTS IT WHEN ANY CHARACTER IS INPUT
134    FROM THE KEY BOARD

```

```

135                                     *IF ITEM IS TO STAY THE SAME
                                     *JUST INPUT A CARRIAGE RETURN (CR)

```

```

136    0171 86 FB    SET    LDA A  #$FB      STOPS CLOCK
137    0173 B7 C111    STA A  CMDR
138                                     *
139    0176 CE 029B          LDX     #HSS      STRING FOR .01 SEC
140    0179 BD E07E          JSR     PDAT1
141    017C BD 01E3          JSR     INTIM
142    017F 25 03           BCS     ++5
143    0181 B7 C100          STA A  HSEC
144                                     *
145    0184 CE 026C          LDX     #SECS    STRING FOR SECONDS
146    0187 BD E07E          JSR     PDAT1
147    018A BD 01E3          JSR     INTIM
148    018D 25 03           BCS     ++5
149    018F B7 C103          STA A  SEC
150                                     *
151    0192 CE 02D0          LDX     #MINS    STRING FOR MINUTES
152    0195 BD E07E          JSR     PDAT1
153    0198 BD 01E3          JSR     INTIM
154    019B 25 03           BCS     ++5
155    019D B7 C102          STA A  MIN
156                                     *
157    01A0 CE 02FB          LDX     #HRS     STRING FOR HOURS
158    01A3 BD E07E          JSR     PDAT1
159    01A6 BD 01E3          JSR     INTIM
160    01A9 25 03           BCS     ++5
161    01AB B7 C101          STA A  HR

```

```

162      *
163      01AE CE 0322      LDX      #DAYMS STRING FOR DAY
                                OF MONTH
164      01B1 BD E07E      JSR      PDAT1
165      01B4 BD 01E3      JSR      INTIM
166      01B7 25 03      BCS      ++5
167      01B9 B7 C105      STA A    DAYM
168      *
169      01BC CE 0346      LDX      #MONTH STRING FOR MONTH
170      01BF BD E07E      JSR      PDAT1
171      01C2 BD 01E3      JSR      INTIM
172      01C5 25 03      BCS      ++5
173      01C7 B7 C104      STA A    MMONT
174      *
175      01CA CE 0363      LDX      #YRS
176      01CD BD E07E      JSR      PDAT1
177      01D0 BD 01E3      JSR      INTIM
178      01D3 25 03      BCS      ++5
179      01D5 B7 C106      STA A    YR

180      *WAIT FOR ANY CHARACTER

181      01D8 BD E1AC      JSR      $E1AC  INPUT CHARACTER
182      01DB 86 F3      LDA A    #$F3    STARTS CLOCK
183      01DD B7 C111      STA A    CMDR
184      01E0 7E 7103      JMP      $7103  SOFT ENTRY FOR DOS

185      *
186      * INTIM IS SUB TO INPUT TIME ITEM

187      *SETS CARY AND RETURNS IF CR WAS INPUT
188      *THIS INDICATES NO CHANGE

189      *IT CLEARS CARRY AND RETURNS IF DATA INPUT
190      *

191      01E3 C6 00      INTIM  LDA B    #0
192      01E5 BD E1AC      JSR      IN
193      01E8 81 0D      CMP A    #$D
194      01EA 26 02      BNE      AR22

```

195	01EC	0D		SEC
196	01ED	39		RTS
197	01EE	84	CF	AR22
198	01F0	81	00	
199	01F2	27	05	
200	01F4	CB	0A	LP21
201	01F6	4A		
202	01F7	26	FB	
203	01F9	BD	E1AC	AR21
204	01FC	84	CF	
205	01FE	1B		
206	01FF	43		
207	0200	0C		
208	0201	39		

209                   \* STRINGS TO BE PRINTED TO SCREEN:

210	0202	0D	OPENS	FCB	\$0D,\$0A,\$0A
211	0205	53		FCC	'S TO SET TIME, Q TO QUIT, ANYTHING ELSE TO READ TIME AGAIN
212	0239	0D		FCB	\$0D,\$0A,4
213	023C	0D	STRING	FCB	\$0D,\$0A
214	023E	20		FCC	' .01S, SEC, MIN, HRS, DATE,MONTH, YEAR'
215	0269	0D		FCB	\$0D,\$0A,4
216	026C	0D	SECS	FCB	\$0D,\$0A
217	026E	49		FCC	'INPUT NUMBER OF SECONDS 2DIGITS NO CR (54)?'
218	029A	04		FCB	4
219	029B	0D	HSS	FCB	\$0D,\$0A
220	029D	49		FCC	'INPUT NUMBER OF 1/100 SECONDS 2DIGITS NO CR (23)?'
221	02CF	04		FCB	4
222	02D0	0D	MINS	FCB	\$0D,\$0A
223	02D2	49		FCC	'INPUT NUMBER OF MIN 2DIGITS NO CR (59)?'
224	02FA	04		FCB	4

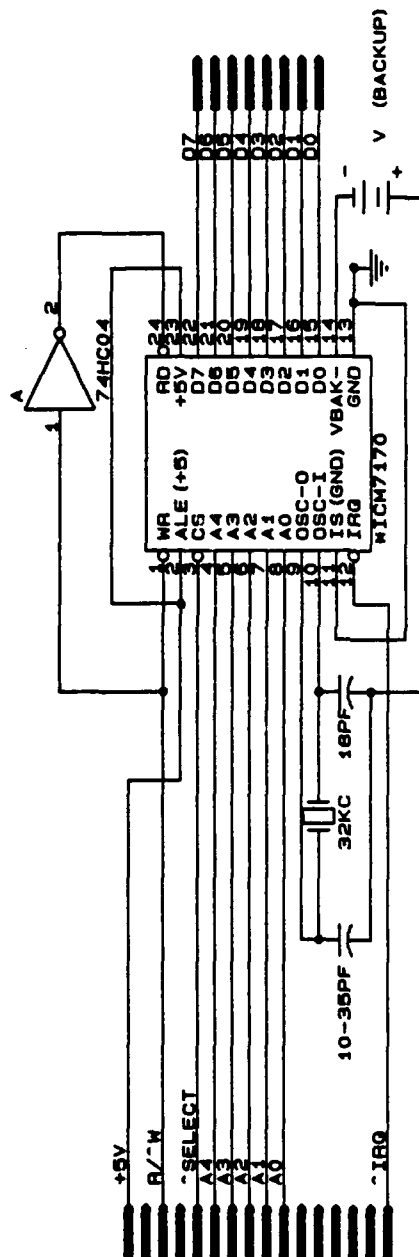
225	02FB 0D	HRS	FCB	\$0D,\$0A
226	02FD 49		FCC	'INPUT NUMBER OF HOURS 2DIGITS NO CR (23)?'
227	0321 04		FCB	4
228	0322 0D	DAYMS	FCB	\$0D,\$0A
229	0324 49		FCC	'INPUT DAY OF MONTH NO CR 2DIGITS (21)?'
230	0345 04		FCB	4
231	0346 0D	MONTH	FCB	\$0D,\$0A
232	0348 49		FCC	'INPUT MONTH 2DIGITS NO CR (11)? '
233	0362 04		FCB	4
234	0363 0D	YRS	FCB	\$0D,\$0A
235	0365 49		FCC	'INPUT YEAR 2DIGITS NO CR (41)? '
236	037E 04		FCB	4
237		*		
238	037F 00	OUT	FCB	0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
239	038F 0002	XTMP	RMB	2
240	0391 0001	BTMP	RMB	1
241			END	

SYMBOL TABLE  
NAME      HEX LOCATION

242	IN	E1AC
243	PDAT1	E07E
244	CMDR	C111
245	HSEC	C100
246	SEC	C103
247	MIN	C102
248	HR	C101
249	DAYM	C105

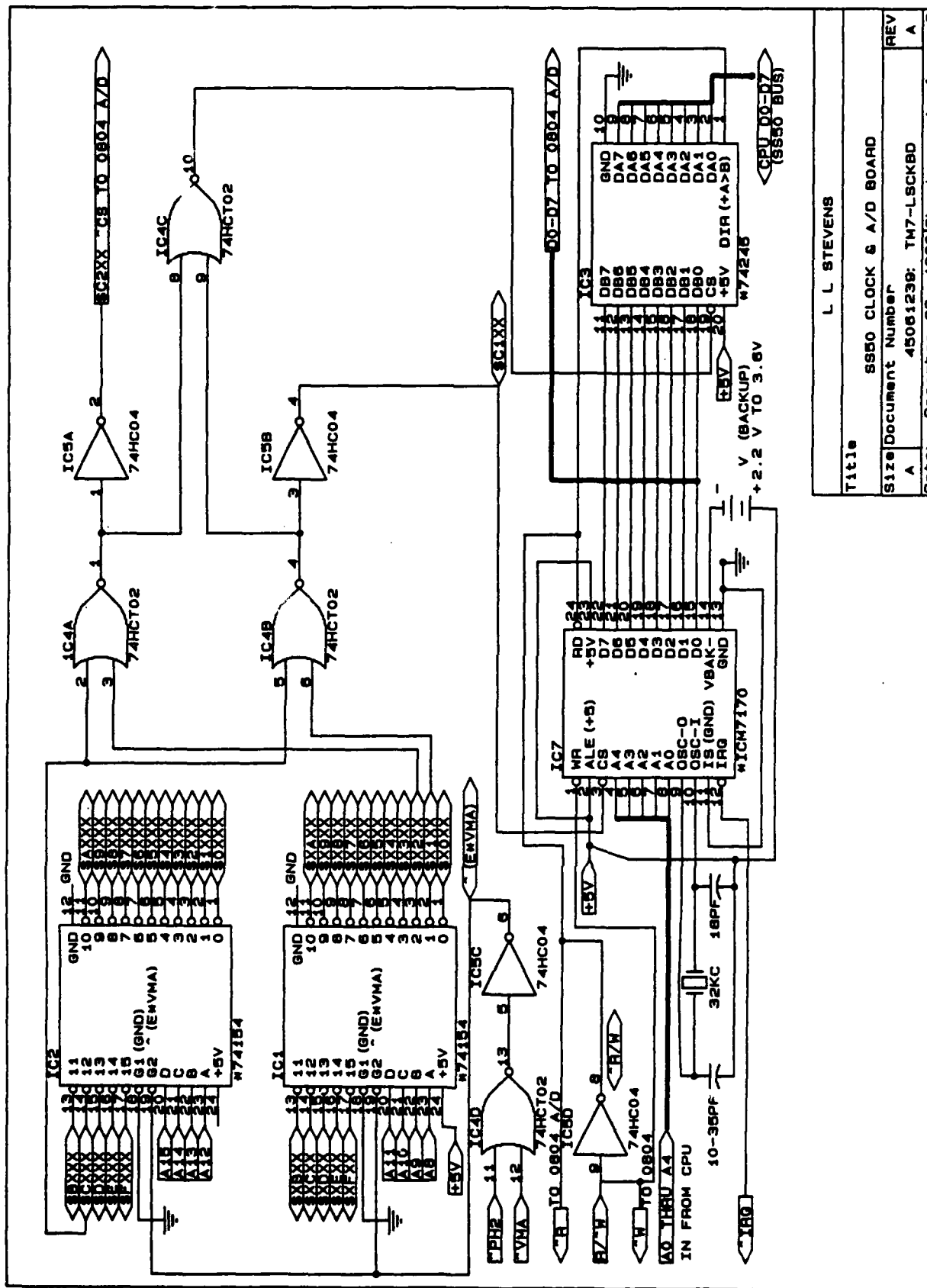


250	MMONT	C104
251	YR	C106
252	DAYW	C107
253	START	0100
254	LP1	0146
255	DN1	016E
256	SET	0171
257	INTIM	01E3
258	AR22	01EE
259	LP21	01F4
260	AR21	01F9
261	OPENS	0202
262	STRING	023C
263	SECS	026C
264	HSS	029B
265	MINS	02D0
266	HRS	02FB
267	DAYMS	0322
268	MONTH	0346
269	YRS	0363
270	OUT	037F
271	XTMP	038F
272	BTMP	0391
273		
274	TOTAL ERRORS	00000



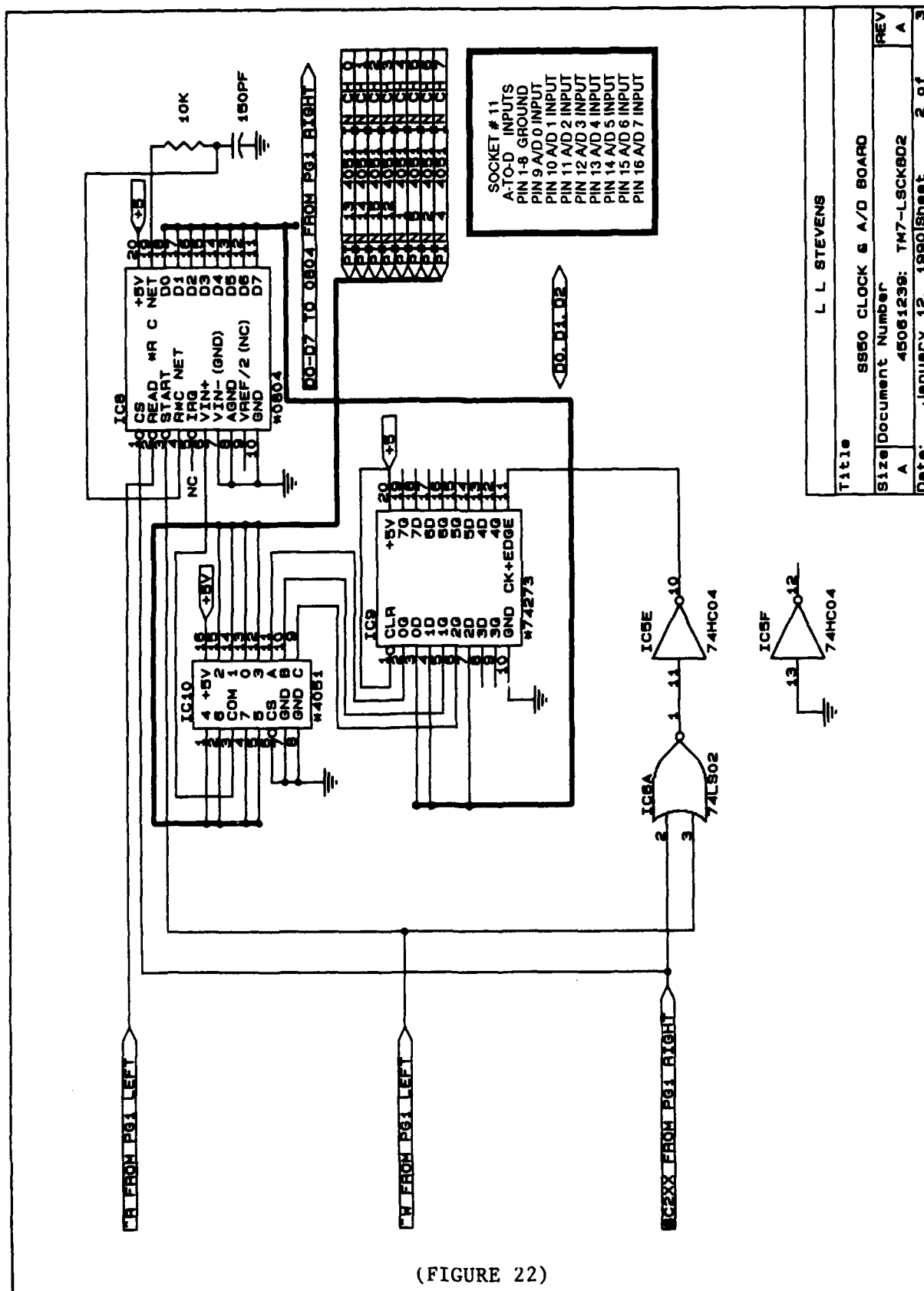
(FIGURE 20)

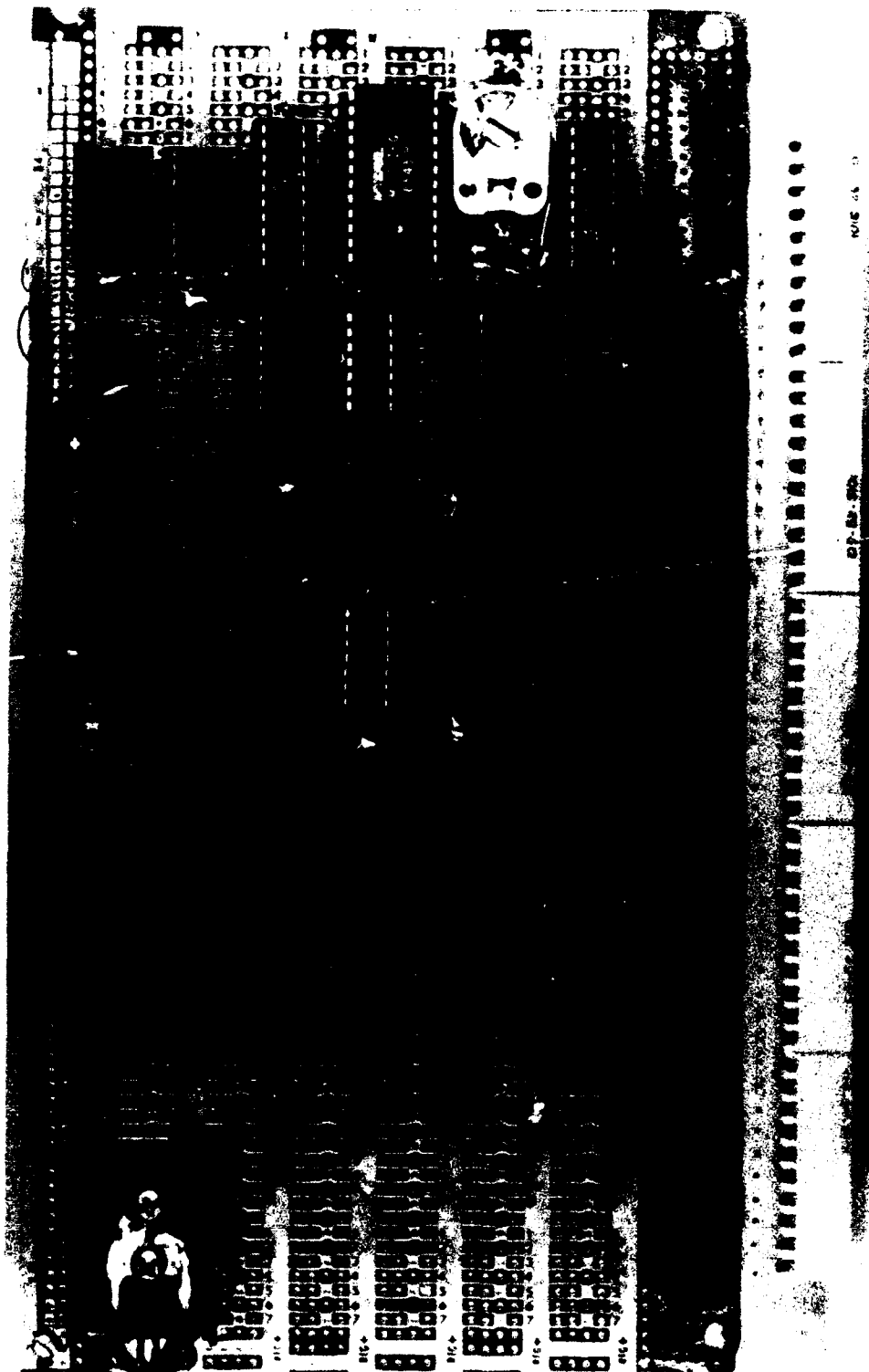
Title		
L L STEVENS		
REAL TIME CLOCK		
Size	Document Number	REV
A	45061239: TM7-LSCLOCK	A
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(FIGURE 21)

Title		S850 CLOCK & A/D BOARD	
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TOP VIEW CLOCK/CALENDAR & A/D BOARD

(FIGURE 23)



BOTTOM VIEW CLOCK/CALENDAR & A/D BOARD

(FIGURE 24)

# SS50 SYSTEM ANALOG TO DIGITAL CONVERTER:

This program was assembled and tested on the SS50(Motorola 6800) system. However, the code is fully compatible with the single board 6802 system. Figures 21 and 22 on pages 108 and 109 show the exact circuit which this program was developed for.

The CMOS single pole eight throw switch selects channel 0 through 9 with the same write command that starts conversion by the analog to digital converter. Binary data is read from the A/D. This data is a binary number between 0 and 255 representing zero volts and 255 representing five volts (actually in the SS50 system the data is inverted by an inverting buffer on the CPU board) so it must be complemented before use. After inversion the raw data is multiplied by two and a duplicate of the raw data is divided by thirty two. The raw/32 is then subtracted from the rawX2 to give the final binary number which represents hundredths of volts input to the A/D plus or minus three hundredths. This binary number is then converted to decimal and printed to the system monitor. The program reads the A/D again with a space input or exits to DOS if a capital Q is entered.

```

1          PAGE 001  AD1
2
3
4
5
6          NAM  AD1
7          OPT  O,S,NOP,NOG
8  0100      ORG  $0100
9          *
10         *
11  E1AC  IN   EQU  $E1AC  INPUTS ONE CHAR
12  E07E  PDAT1 EQU  $E07E  PRINTS STRING TO SCREEN
13  E1D1  OUT  EQU  $E1D1  PRINT ONE CHAR
14  C200  AD   EQU  $C200  A/D DECODE ADDRESS
15  7133  OUTD EQU  $7133  OUT-DECIMAL X-POINT 2-BYTES
16          *          B-FLAG (0=START FIRST NON 0)
17          *          (ELSE=PAD WITH SPACE)

```

18	7139	OUTH	EQU	\$7139	OUT-HEX X-POINT 1-BYTE
19	711E	CRLF	EQU	\$711E	OUT-CR-LF
20	7103	DOS	EQU	\$7103	DOS SOFT ENTRY
21		*			
22		*			* This program reads an analog to
23		*			* digital (A D) converter which is
24		*			* decoded at \$C200 on the SS50 system.
25		*			
26		*			* Eight A/D input lines are connected
27		*			* to a single 0804 A/D converter by
28		*			* a 4051 CMOS switch.
29		*			
30		*			* Figure 21 on page 108 shows the
31		*			* initial decoding for a negative
32		*			* going chip select for the A/D at
33		*			* \$C2XX (XX represents doesn't care).
34		*			* This schematic also indicates how
35		*			* not read and not write signals
36		*			* are generated.
37		*			
38		*			* Figure 22 on page 109 is the
39		*			* schematic diagram for the 4051
40		*			* CMOS switch (IC-10) and 0804
41		*			* A/D converter (IC-8). This diagram
42		*			* also shows a 74273 (IC-9) which
43		*			* is used to latch the line select
44		*			* data into the 4051 switch.
45		*			
46		*			* Two things occur when a number
47		*			* is written into memory location
48		*			* \$C200: first the number written
49		*			* is latched into 74273 to select
50		*			* one of the eight A/D input lines.
51		*			* Second the not write pulse, when
52		*			* \$C2XX is selected, starts
53		*			* conversion by the 0804 A/D (IC-8).
54		*			
55		*			* After conversion, location \$C200
56		*			* may be read to obtain the voltage
57		*			* data from the A/D converter. It



```

58          * should be noted that a not read
59          * pulse is required by the 0804
60          * (IC-8).
61    0100 CE 019B START LDX      #ST2
62    0103 BD E07E      JSR      PDAT1
63    0106 BD E1AC      JSR      IN
64    0109 80 30        SUB A    #30
65    010B 16          TAB
66    010C 86 FF        LDA A    #FF
67    010E 10          SBA
68    010F B7 C200      STA A    $C200    *THIS SELECTS
                                         LINE 0 THRU 9
69          *                                         AND STARTS
                                         CONVERSION
70    0112 BD 015E      JSR      DLY1    *WAIT FOR
                                         CONVERSION
71          *
72    0115 B6 C200      LDA A    $C200    *THIS GETS
                                         DATA
73    0118 43          COM A    *INVERTED
                                         BUFFERS
74    0119 48          ASL A
75    011A 97 01        STA A    1    *PUTS DATA
                                         IN MEM 1
76          *
77    011C B6 C200      LDA A    $C200    *THIS GETS
                                         DATA
78    011F 43          COM A    *INVERTED
                                         BUFFERS
79    0120 44          LSR A
80    0121 44          LSR A
81    0122 44          LSR A
82    0123 44          LSR A
83    0124 44          LSR A
84    0125 44          LSR A
85    0126 44          LSR A
86    0127 97 00        STA A    0
87          *

```

88	0129 F6 C200	LDA B   \$C200	*THIS GETS DATA
89	012C 53	COM B	*INVERTED BUFFERS
90	012D 54	LSR B	
91	012E 54	LSR B	
92	012F 54	LSR B	
93	0130 54	LSR B	
94	0131 54	LSR B	
95		*	NOW HAVE (A/D)/32 IN ACC B
96	0132 96 01	LDA A   1	
97	0134 10	SBA	
98	0135 97 01	STA A   1	
99		*	5V=510-7 (503)
100	0137 96 00	LDA A   0	
101	0139 82 00	SBC A   #0	
102	013B 97 00	STA A   0	
103		*	
104			*PRINT DECIMAL EQUIVALENT OF
105			*TWO TIMES A/D VALUE -(1/32 A/D)
106			*A/D INPUT VOLTAGE IN .01 VOLTS
107	013D BD 711E PRINT	JSR	CRLF
108	0140 CE 0000	LDX	#0 POINT TO BINARY VALUE
109	0143 C6 01	LDA B	#1 PAD SPACES
110	0145 BD 7133	JSR	OUTD
111	0148 CE 0165	LDX	#ST1
112	014B BD E07E	JSR	PDAT1
113	014E BD 711E	JSR	CRLF

```

114      *
115      ***
116      * JSR DLY1
117      * LDAA $C200      INITIALLY
118      * STAA 1          USED TO TEST
119      * JSR DLY1        DELAY REQUIRED
120      * LDAA $C200      FOR A/D TO
121      * STAA 2          CONVERT
122      * JSR DLY1
123      * LDAA $C200
124      * STAA 3
125      * JSR DLY1
126      * LDAA $C200
127      * STAA 4

128      ***
129      *
130      0151 BD E1AC      JSR      IN
131      0154 81 51        CMP A    #$51
132      0156 27 03        BEQ      DN1
133      0158 7E 0100      JMP      START
134      015B 7E 7103 DN1  JMP      $7103      DOS SOFT ENTRY

135      *
136      015E CE 0020 DLY1 LDX      #$20
137      0161 09          LP1    DEX
138      0162 26 FD        BNE     LP1
139      0164 39          RTS

140      *
141      0165 20 ST1      FCC ' .01s VOLT +/-3UNITS'
142      0179 0D          FCB $0D,$0A
143      017B 51          FCC 'Q TO QUIT OR SPACE TO RUN AGAIN'
144      019A 04          FCB 4
145      *

```

146	019B	0D	ST2	FCB	\$D,\$A
147	019D	20		FCC	' SELECT CHANNEL 0 THRU 7 NO-CR'
148	01BA	04		FCB	4
149				END	

# Symbol Table

150	IN	E1AC
151	PDAT1	E07E
152	OUT	E1D1
153	AD	C200
154	OUTD	7133
155	OUTH	7139
156	CRLF	711E
157	DOS	7103
158	START	0100
159	PRINT	013D
160	DN1	015B
161	DLY1	015E
162	LP1	0161
163	ST1	0165
164	ST2	019B
165		
166		TOTAL ERRORS 00000
167	EOF	